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Determination of Residual Chlorine and Turbidity in Drinking Water: Student Manual

(U.S.) National Training and Operational Technology Center, Cincinnati, OH

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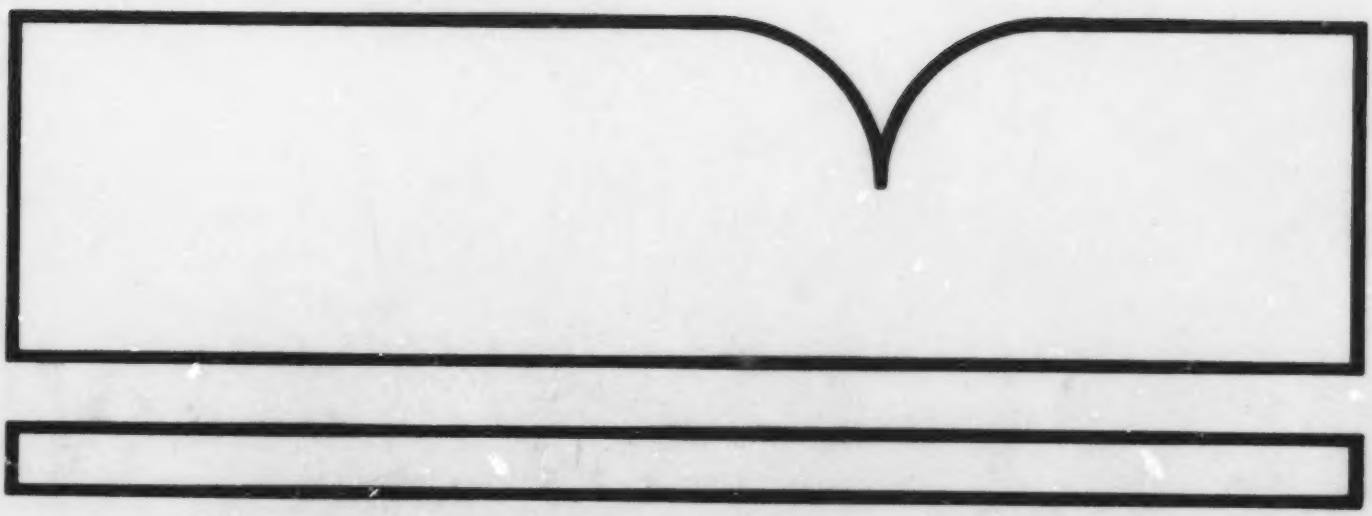

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Determination of Residual Chlorine and Turbidity in Drinking Water

Student Manual

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This classroom/laboratory manual is for use by operators of drinking water plants who must analyze samples for residual chlorine and turbidity. It contains background information on both tests; e.g., Federal requirements for compliance on residual chlorine and turbidity, principles involved in the tests, and factors affecting test results. It also contains laboratory procedures for conducting the two tests. Reagent preparation and instrument care are included. Miscellaneous other items are in the manual: an agenda, if the manual is to be used in the presentation of a training course, a pre- and post-course test, and a copy of the Federal Register which relates to the measurement of residual chlorine and turbidity. For those who desire to present instruction in these two determinations, there is an associated Instructor's manual (EPA 430/1-78-011) title as above.

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DETERMINATION OF RESIDUAL CHLORINE AND TURBIDITY IN DRINKING WATER

This manual was developed by the U.S. Environmental Protection Agency, National Training and Operational Technology Center in response to a request from the Office of Drinking Water.

STUDENT MANUAL

National Training and Operational Technology Center
Municipal Operations and Training Division
Office of Water Program Operations
U.S. Environmental Protection Agency

DISCLAIMER

Reference to commercial products, trade names, or manufacturers is for purposes of example and illustrations. Such references do not constitute endorsement by the Office of Water Program Operations, U.S. Environmental Protection Agency.

This manual has been prepared from the National Interim Primary Drinking Water Regulations and the references contained therein which constitute the legal authority for these procedures. When used within a State having been granted primary enforcement authority, that State's regulations will then constitute the legal authority and should be followed.

INTRODUCTION

DETERMINATION OF RESIDUAL CHLORINE AND TURBIDITY IN DRINKING WATER

When Congress passed the Safe Drinking Water Act, they required the U.S. EPA to set maximum contaminant levels (MCL's) for chemical, bacteriological and radiological contaminants. The U.S. EPA responded to this with the National Interim Primary Drinking Water Regulations (NIPDWR). As part of these regulations, turbidity and chlorine had certain requisites set down.

It was intended in the Safe Drinking Water Act (SDWA) that the States have primary enforcement responsibilities after adoption of their own regulations which were to be no less stringent than those contained in Federal regulations.

Since samples for residual chlorine and turbidity cannot be preserved for shipment to laboratories, analysis for these parameters are to be run by any person acceptable to the State, i.e., the responsible authority. These persons will be in all probability the operators of the treatment plants. It is expected that the States will set up some form of training and/or approval of these analysts.

This manual was developed to meet the needs of training the operators in the correct procedures for analysis. The material contained herein was based on the Federal document and when used by the States, should be proofed for any differences.

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Excerpts from:

The Manual for the Interim Certification of Laboratories Involved in Analyzing Public Drinking Water Supplies

The Comments to the Proposed NIPDWR's

FEDERAL REQUIREMENTS FOR COMPLIANCE ON CHLORINE AND TURBIDITY

1. The reason for the MCL on turbidity is because turbidity

   a. may interfere with disinfection
   b. makes water look bad
   c. makes water taste bad
   d. may settle out in the distribution system
   e. may shorten filter runs

2. The MCL for turbidity is applicable to

   a. all public and private water supplies
   b. all community and non-community supplies
   c. only community supplies
   d. all community and non-community supplies which use surface waters
   e. all community and non-community supplies which use ground waters

3. The turbidity sample must be taken

   a. in the plant
   b. anywhere
   c. at the entry point to the distribution system
   d. at the end of the distribution system
   e. somewhere in the distribution system

4. The MCL, based on a monthly average, for turbidity is

   a. 5 TU's
   b. 3 TU's
   c. 2 TU's
   d. 1 TU
   e. 0.5 TU's

5. Analysis for turbidity must be carried out by

   a. anyone acceptable to the State
   b. the Federal regional personnel
   c. a laboratory that the State has approved
   d. the State personnel
   e. the consumer

6. The analysis for residual chlorine is required

   a. because it is published in the regulatory document
   b. because it is a health hazard
   c. to assure a residual in the distribution system
   d. to monitor for filter breakthrough
   e. only if substitution is carried out

7. Substitution may be carried out if

   a. the operator wishes to substitute
   b. only after the State has received primary responsibility
   c. only after approval has been granted by the State
   d. only if the supply is chlorinating
   e. only if the State grants a blanket approval for a substitution

8. The level of free residual chlorine that must be maintained in the distribution system if substitution is practiced is

   a. 0.1 mg/liter (ppm)
   b. 0.2 mg/liter (ppm)
   c. 0.3 mg/liter (ppm)
   d. 0.4 mg/liter (ppm)
   e. 0.5 mg/liter (ppm)

9. The maximum number of microbiological samples that may be substituted for are

   a. 75%
   b. 50%
   c. depends on the size of the plant
   d. 25%
   e. depends on who does the analysis

10. If the required levels for chlorine and/or turbidity are not met, the supply must notify

    a. the State
    b. the consumers
    c. the Federal region
    d. the State and federal region
    e. the State and the consumers

ANALYSIS FOR CHLORINE

1. The approved method for analysis of free residual chlorine in drinking water is the

   a. Orthotolidine
   b. amperometric titration
   c. DPD test
   d. iodometric
   e. OTA

2. The "Kit" or Comparator form of the approved method

   a. can be used if approval granted
   b. must be applied for under alternative test procedures
   c. may not be used
   d. may be used
   e. can be used only for operational testing

3. The chlorine sample is to be taken

   a. in the plant
   b. at the first tap
   c. at the entrance to the distribution system
   d. at the end of the system
   e. at points representative of the conditions within the distribution system

4. The sample for chlorine may _____ be for analysis.

   a. be held overnight
   b. be held 24 hours
   c. be held 48 hours
   d. not be held longer than one hour
   e. be held for 2 hours

5. The analysis for chlorine must be done for _____ chlorine

   a. total
   b. combined
   c. mono and dechloramines
   d. free
   e. total and free

6. It is recommended that the visual standards in the chlorine kit _____ _____.

   a. do not need calibration
   b. need calibration before each use
   c. need calibration every week
   d. need calibration every month
   e. need calibration every six months

7. The test for chlorine must be read _____ after addition of the reagent.

   a. within one minute
   b. within three minutes
   c. any time
   d. within one hour
   e. within five minutes

8. One procedure for calibrating the visual standards for chlorine involves the use of _____.

   a. a chlorine solution
   b. a manufacturer's standard
   c. an orthotolidine standard
   d. potassium permanganate
   e. chlorobenzene standard

9. Analysis for chlorine may be done by the _____ procedure.

   a. DPD colorimetric (spectrophotometer)
   b. DPD titrimetric
   c. DPD comparator
   d. any
   e. OTA kit

10. Analysis for chlorine must be carried out by

   a. any one acceptable to the State
   b. the Federal regional personnel
   c. a private laboratory the State has approved
   d. the State personnel
   e. the consumer

ANALYSIS FOR TURBIDITY

1. Which of the following units may be used to express turbidity values?

   a. NTU's
   b. FTU's
   c. mg/l's (ppm)
   d. JTU's
   e. TU's

2. Turbidity measurements must be made

   a. a number of times based on the population served
   b. hourly
   c. daily
   d. monthly
   e. quarterly

3. The method to be used to measure turbidity is based upon

   a. transmission of light
   b. absorption of light
   c. scattering of light
   d. the use of the Jackson Candle turbidimeter
   e. nephelometry

4. The standards supplied by the manufacturer

   a. do not need calibration
   b. need to be replaced only if broken
   c. need to be monitored for deterioration every six months
   d. need to be calibrated once
   e. need to be monitored for determination every month

5. The method for calibration of the turbidimeter is the use of

   a. the Jackson Candle
   b. formazin
   c. Fuller's earth
   d. a filter
   e. a plastic rod

6. The stock turbidity formazin suspension (400 units) is stable for

   a. one day
   b. three days
   c. one week
   d. three weeks
   e. one month

7. Good practice for handling the sample cells used in the turbidimeter include

   a. a wiping with a soft tissue before placing it in the instrument
   b. not touching it where the instrument's light strikes it
   c. discard the sample cells when scratched
   d. keep the cells very clean
   e. store the cells in a safe place

8. The user of a turbidimeter _____ stock (400 unit) formazin suspension.

   a. must have the State prepare his
   b. may purchase the
   c. may do his own preparation of the
   d. does not need a
   e. none of the above

9. Dilutions of the stock formazin suspension should be used for

   a. one day
   b. one week
   c. one month
   d. two months
   e. indefinitely

10. The maximum reading on a turbidimeter that may be used without dilution is

   a. 1000 TU's
   b. 400 TU's
   c. 100 TU's
   d. 40 TU's
   e. 10 TU's

DETERMINATION OF RESIDUAL CHLORINE AND TURBIDITY
IN DRINKING WATER

Date
Location

EXAMPLE AGENDA

Course Director:

DAY & TIME	SUBJECT	SPEAKER
Monday, July 24		
8:30 - 9:30	Registration, Introduction and Pre-Test	
9:30 - 10:15	Federal (State) Requirements for Compliance on Chlorine and Turbidity	
10:15 - 10:30	Break	
10:30 - 11:00	Analysis for Chlorine	
11:00 - 12:00	Analysis for Turbidity	
12:00 - 1:00	Lunch	
1:00 - 1:30	Laboratory Briefing	
1:30 - 4:00	Laboratory: 1. Chlorine Kit Standardization 2. Turbidity Preparation of Standard Standardization of Instrument	
4:00 - 4:30	Course Closing	

Federal Requirements for Compliance on Chlorine and Turbidity

I. Introduction

The Safe Drinking Water Act (PL 93-523) was signed by the President on December 16, 1974. It is the first Federal act dealing in depth with providing safe drinking water for public use. Prior to this act, only the Interstate Carrier Water Supply Certification Program could be used on a Federal level to certify public water supplies. Consequently, the Safe Drinking Water Act was adopted to insure a safe and adequate water supply to all persons.

As part of the Safe Drinking Water Act, Congress mandated that the Environmental Protection Agency publish proposed drinking water regulations within 90 days of enactment of the Act. After an appropriate time (180 days) for receipt of public comments, EPA was to promulgate such regulations, with modifications as were deemed appropriate.

Consequently, the National Interim Primary Drinking Water Regulations (NIPDWR) were promulgated on December 24, 1975. These regulations were to become effective on June 24, 1977.

The Safe Drinking Water Act anticipated that the States, after meeting certain requirements, were to become the primary enforcement authority for the Act and the Primary Regulations. The corresponding regulations adopted by the States were to be no less stringent in their requirements than the Federal regulations.

The NIPDWR set down a list of contaminants, their maximum contaminant levels (MCL), the monitoring frequency, and the analytical method to be used in their analysis. These contaminants included inorganic and organic chemicals, microbiological and radiological parameters. In addition, such topics as variances and exemptions, siting requirements, reporting, public notification and record keeping were covered.

The two parameters we are to deal with in this course are the requirements for chlorine residual and turbidity.

II. Chlorine

While chlorine itself is not listed as a parameter requiring monitoring, it is covered under the microbiological section. The NIPDWR requires a water supplier to collect samples to be analyzed for coliform bacteria at regular time intervals. The number of samples to be collected are in proportion to the population served by the system. A table is supplied in the document listing the minimum number of samples per month to be taken when a certain population is served with the sampling frequency ranging from one sample per month to 500 samples per month.

In an effort to reduce the required bacteriological analysis for both community and non-community water supplies, substitution of free chlorine residual determinations was permitted in the NIPDWR. This substitution is subject to approval by the State and must be based upon a sanitary survey of the supply and permits substitution of no more than 75% of the required bacteriological samples.

In order to carry out this substitution the supplier of water must take chlorine residual samples at points which are representative of the conditions within the distribution system; at a frequency of at least four for each substituted microbiological sample. In addition, there must be at least daily determinations of residual chlorine. No less than the level of 0.2 mg/liter of free chlorine must be maintained throughout the distribution system.

Substitution for small numbers of bacteriological samples may not be economically advantageous. For example, if three bacteriological samples per month are required, two could be substituted. This would require four times the two or eight residual chlorine determinations. However, if any substitution is done, at least one chlorine determination must be done daily or about thirty per month. Consequently, there would be an increased workload created by substitution.

Should a sample from some particular sampling point be found to contain less than 0.2 mg/liter free chlorine, the water at this point shall be retested as soon as possible and in any event within one hour. If the resample analysis reconfirms the original analysis in that less than 0.2 mg/liter free chlorine is present, the fact shall be reported to the State within 48 hours. In addition, when confirmation is obtained, a sample must be taken from the same sampling location and analyzed for coliform bacteria. This additional sample must be taken as soon as possible and preferably within one hour. The results of this bacteriological analysis shall be reported to the State within 48 hours after the results are known to the water supplier.

Under section 141.32, Public Notification, it is further stated that if a community water system should fail to comply with the required level of 0.2 mg/liter of free chlorine residual, the supplier shall notify the persons served by the system of the failure to comply. How this notification is to be carried out and with what frequency, can vary with the State document and should be discussed with the State's representative by the supplier.

It should be made clear that substitution is permitted only with permission of the State and this approval may be withdrawn at any time. Some States are not permitting substitution at all in their corresponding document for drinking water quality. Any supplier should check with his State before beginning to substitute free chlorine determinations for bacteriological analysis.

Concerning the subject of who should do the analysis for free chlorine residual, the NIPDWR state that anyone acceptable to the authority may perform the analysis. It is urged that the State set up some quality control guidelines for the analysis as well as having a system to assure validity of these data.

As mentioned earlier, samples should be taken at points in the distribution system that are representative of that system. When small numbers of samples are taken, the locations should be varied so as to obtain information on the entire system. One good sampling location would be the farthest point away from the supply that the water travels. Caution should be taken not to use samples taken for bacteriological purposes for chlorine determinations as chemicals are added to the bacteriological sample bottles to destroy the residual chlorine.

The Statement of Basis and Purpose for the National Interim Primary Drinking Water Regulations lists four items which should be specified by the State when allowing substitution, they are:

A. The number and location of samples for which chlorine residuals are to be substituted,

B. The form and concentration of chlorine residual to be maintained,

C. The frequency of chlorine residual determinations; and

D. The analytical method to be used.

Each approval must be made on a case-by-case basis taking into account individual circumstances. The requirement is the establishment of the relationship between chlorine residual and the absence of total coliform in any given water. This may not be too difficult in larger supplies where both of these measurements are routinely made, but it might be quite difficult for the smaller suppliers (where the most help is needed) who have not been making either measurement.

III. Turbidity

Turbidity, unlike chlorine, is a parameter that is specifically mentioned in the NIPDWR. Drinking water should be low in turbidity prior to disinfection and at the consumers tap for the following reasons:

First, several studies have demonstrated that the presence of particulate matter in water interferes with effective disinfection.

Secondly, it was revealed in the 1969 Community Water Supply Survey that unpleasant tastes and odors were among the most common customer complaints. While organics and inorganics in finished water may cause tastes and odors, these problems are often aggravated by the reaction of chlorine with foreign substances. Maintenance of low turbidity will permit distribution of water with less likelihood of creating increased taste and odor.

Thirdly, regrowth of microorganisms in a distribution system is often stimulated if organic matter (food) is present. One source of the food is biological forms such as algae which may contribute to gross turbidity. Therefore the maintenance of low turbidity water will reduce the level of this microbial food and maintain a cleanliness that will help prevent regrowth of bacteria and the growth of other microorganisms.

And lastly, the purpose of maintaining a chlorine residual in a distribution system is to have a biocidal material present throughout the system so that the consumer will be protected if the integrity of the system is violated. Because the suspended material that causes turbidity may exert a chlorine demand, the maintenance of a low turbidity water throughout the system will facilitate the maintenance of proper chlorine residual.

The maximum contaminant levels for turbidity are applicable to both community and non-community water systems using surface waters in whole or in part as their source.

The maximum contaminant levels are:

A. One turbidity unit (TU) as determined by a monthly average. Except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not do any of the following:

   1. Interfere with disinfection
   2. Prevent maintenance of an effective disinfectant agent throughout the distribution system; or
   3. Interfere with microbiological determinations

B. Five turbidity units based on an average for two consecutive days.

The samples should be taken by the supplier of water for both community and non-community systems. The samples should be taken at a representative point of entry into the distribution system at least once a day. The sample may be taken and analyzed by anyone acceptable to the principal enforcement authority whether State or Federal, and analyzed as soon as possible or within one hour.

If the results of the turbidity analysis indicates that the maximum allowable limit has been exceeded, the sampling and analysis must be repeated from the same location as soon as practicable and preferably within one hour. If the repeat sample confirms that the maximum allowable limit has been exceeded, the supplier of the water shall report to the State within 48 hours. The repeat sample shall be the sample used for the purpose of calculating the monthly average. If the monthly average of the daily samples exceeds the maximum allowable limit, or if the average of two samples taken on two consecutive days exceeds 5 turbidity units, the supplier of the water shall report to the authority and notify the public as directed by the regulations.

IV. Public Notification

In an attempt to protect the consumer of water, a requirement of public notification was established in the Act. In addition to protection, it also serves to keep the consumer up to date on actions taken to correct the reason for notification. Notification is required if a supply:

A. Fails to comply with a MCL
B. Fails to comply with testing and/or monitoring requirements
C. Fails to comply with any compliance schedule; or
D. Is granted a variance or exemption

Notification must be included in any water bills sent the consumer or by mail. Additionally, in the event of a failure to comply with a MCL, the notification should also be carried out in newspapers, and on radio and television. In all instances, the notification should be conspicuous and in an easily readable and understandable form.

The State may require additional notification in the various forms for failure to comply with testing, monitoring, compliance schedules or if variances or exemptions are granted.

V. Summary

In the monitoring and analytical requirements section for microbiological contaminants, a number of samples are required to be analyzed, depending on the population served, by the the supply. In an effort to reduce this workload, substitution of up to 75% of the required microbiological analyses with analyses for free residual chlorine was permitted. Four chlorine determinations for each substituted bacteriological analysis was the frequency required. The regulations also require that the analytical method to be used for this analysis was to be in the kit form of the DPD procedure.

Turbidity is a contaminant which has a set MCL of one turbidity unit allowed in finished waters. The monitoring frequency is required to be carried out daily at the point of entry of the water into the distribution system. The analytical method utilizing Nephelometry is required to comply with the regulations.

References:

1. Federal Register, Part IV, December 24, 1975, National Interim Primary Drinking Water Regulations, pages 59566-59574.

2. Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971, APHA-AWWA-WPCF, 1015 18th St. N.W., Washington, DC 20036.

This outline was prepared by: J. D. Pfaff, Chemist, National Training and Operational Technology Center, MOTD, OWPO, USEPA, Cincinnati, OH 45268

Analysis for Free Chlorine Residual

I. Introduction

The analysis for free residual chlorine for compliance with the National Interim Primary Drinking Water Regulations (NIPDWR) is quite simple. The Regulations in section 141.21(h) stipulate that "Analysis for residual chlorine shall be made in accordance with Standard Methods for the Examination of Water and Wastewater, 13th edition, pages 129-132." These page references cover the DPD Ferrous Titrimetric and Colorimetric methods.

For many years the method used in drinking water treatment plants to measure chlorine concentrations was the orthotolidine method utilizing the color comparator. However, the orthotolidine test has been shown to be inaccurate and unreliable. The Environmental Protection Agency felt that a more reliable method that maintained simplicity by using a comparator kit should be used. Consequently, it was intended when the regulations were written, that the DPD method, which is available in the kit form, be used. Because the kit form is available and permitted, should not imply that the colorimetric or the titrimetric forms may not be used.

II. Basic Principal

A. Forms of Chlorine

Elemental chlorine is a greenish-yellow gas that is highly soluble in water. It reacts readily with many inorganic substances and all animal and plant tissues. The denaturing affect of chlorine on animal and plant tissues forms the basis for its use as an effective water and wastewater disinfectant. When chlorine dissolves in water, it acts according to the reaction: $Cl_2+H_2O \rightarrow HOCl+H^++Cl^-$. Unless the concentration of the chlorine solution is above 1000 mg/liter, all chlorine will be in the form of HOCl (hypochlorous acid) or its dissociated ions H^+ and OCl^- (hypochlorite ion). The HOCl is a weak acid and is dissociated according to the equation $HOCl \rightleftarrows H^+ + OCl^-$.

The ratio between HOCl and OCl is dependent on the pH of the water, with 96% HOCl remaining at pH 6, 75% at pH 7, 22% at pH 8 and 3% at pH 9. The relationship of HOCl to pH is significant as this form is the most potent bactericidal form in the use of chlorine for disinfection.

Chlorine in the free form reacts readily with nitrogenous organic materials to form chloramines. The chloramines, mono and dichloramine, make up the combined forms of chlorine. It is generally recognized that the combined forms of chlorine have a markedly less disinfecting efficiency than free chlorine. It is for this reason a required level of at least 0.2 mg/liter of free chlorine is to be maintained throughout the distribution system.

B. Methodology

One point which must be kept in mind as the method is discussed is that the only form of chlorine that is required to be measured by the regulations is the free chlorine. When the procedure is read in "Standard Methods," it appears to be involved and sophisticated and may tend to cause anxiety towards its use. The kit form simply requires the

addition of a solid reagent (in powder or tablet form) to a measured volume of sample and comparison of the resulting instantaneous color with a standardized color.

In the absence of iodide ion, free available chlorine reacts instantly with the DPD (N, N-diethyl-p-phenylenediamine) reagent to produce a red color. The color produced is more stable, and fewer reagents are needed, than with the orthotolidine test. With addition of potassium iodide (KI) additional information on the concentration of the combined forms of chlorine (mono or dichloramines) can be determined.

III. Instrument Design:

As mentioned before the "Kit" form of the DPD method was the method intended for use in the measurement of free residual chlorine in the NIPDWR. In most instances, the kit is a color comparator in which the analyst compares the color produced in the sample with a series of visual standards. These visual standards are normally in one of two forms, a plastic disc or liquid containing sealed ampules. Both of these have colors matching the colors produced in the DPD test with various concentrations of chlorine.

These visual standards are either sealed in the comparator or replaceable. Sample cells are provided in which the sample and reagents are placed and the resulting color viewed along side the visual standards.

This outline is meant to cover only the kit form, however, it does not intend to imply that the use of the colorimetric and/or titrimetric procedures listed in "Standard Methods" are any less acceptable. These other procedures are more expensive and difficult but produce equally acceptable data. The reader should consult the references for further information on these procedures.

IV. Factors Affecting the DPD Test

There are more interferences affecting the DPD test than those covered here. However, since compliance with the NIPDWR requires only the free chlorine to be measured, only those interferences connected with this measurement are covered. Should additional information be required, refer to the references at the end of this chapter.

Chlorine dioxide, bromine, bromamine, iodine and any oxidized manganese may react with the DPD reagent and give results as free residual chlorine. Chlorine dioxide appears as free chlorine in the DPD procedure but only to the extent of one-fifth of its total available chlorine content. If this proves to be a particular problem in a treatment plant, the free residual chlorine can be determined by doing two determinations and subtracting the values. The first run is done normally by adding the reagent and reading the color. This will produce a combined value for free chlorine and chlorine dioxide interference. A second volume of sample is taken and 0.1 milliliter of a 10% w/v solution of glycine is added. The solution is mixed, the DPD reagent is added, and the reading taken immediately. This value will represent the chlorine dioxide interference. The value determined secondly, i.e., when the glycine is used, is subtracted from the value obtained in the normal procedure to produce a value for the free residual chlorine only.

In a similar manner two runs can be carried out to differentiate between the free residual chlorine and any bromine, bromamine or iodine present. Again, the first time the sample is analyzed in a normal fashion, this provides a value for the chlorine, bromine, bromamine and iodine. Then a second volume of sample is taken and about 0.05 grams (a small pinch) of ammonium sulfate ($(NH_4)_2SO_4$) is added and, after mixing to dissolve, allowed to stand one minute. Then the DPD reagent is added and the reading taken. This value represents the bromine, bromamine and iodine. By subtracting the second value (when ammonium sulfate is added) from the first determination, the free residual chlorine value is obtained.

Extremes in pH can cause additional interferences, however, with the phosphate buffer included as required, with the DPD reagent, the pH will not go to these extremes. The buffer is incorporated in the dry reagent used with the kits.

Temperature can cause interference as it does in most methods. The higher the temperature, the greater the tendency for the chloramines to produce increased apparent free chlorine results after a fixed time interval. However, the DPD method is among those methods least affected by temperature.

The amount of reagent included (tablet or powder) in the kit is generally good for concentrations up to 4 mg/liter free residual chlorine. Samples with concentrations higher than this should be diluted and the results multiplied by the appropriate dilution factor.

The last comment to be made here is that the analysts who have difficulties in detecting colors or differentiating shades of red will have difficulties in carrying out this analysis. However, the titrimetric or colorimetric (used with a spectrophotometer) procedures could be used in place of the visual comparison kit method.

V. Calibration

In the document currently being used as criteria for the certification of laboratories doing analysis to comply with the NIPDWR, certain recommendations are made for the calibration of the visual standards in the kits. Laboratories utilizing visual comparison devices such as color wheels, sealed ampules, etc., should calibrate the standards incorporated into such devices at least every six months with documentation of these calibrations. By preparing check standards (in Standard Methods) and comparing these with the manufacturer's standards and plotting such comparisons on graph paper, a correction factor can be derived and applied to all future results obtained on the now calibrated apparatus.

This constant calibration will monitor for any deterioration of the kit's visual standards. In addition, if one or two check standards are prepared each time a new batch of DPD reagent is purchased, the analyst can be aware of any changes in the prepared reagent's strength or makeup which may result in deviations from past calibrations.

Directions for preparing visual check standards can be found in Standard Methods. In order to calibrate the permanent standards, a solution of potassium permanganate ($KMnO_4$) can be prepared that will be equivalent to 1 mg/liter of chlorine. This solution is prepared by dissolving 891 mg of potassium permanganate per liter of distilled water and diluting 10 ml of

this solution to one liter. Thereafter 1 ml of this freshly prepared solution, when made up to 100 ml with distilled water, will produce the color associated with 1 mg/liter of chlorine with the addition of DPD. A series of dilutions covering the range of the standards in the comparator should be prepared to check each permanent standard. More precise directions and an example series of dilutions will be found in the laboratory section of this manual.

Potassium permanganate ($KMnO_4$) can be purchased from any laboratory supply catalog. A good grade, ACS or reagent grade, should be purchased. Purchase about one pound (453 grams) of the material. This is usually the smallest amount sold. If the material is kept tightly closed and in a dry area, it should last for a long time. However, the solutions of the potassium permanganate should be prepared fresh before each use to ensure correct results.

Quality control samples will be available from Quality Assurance Branch, Environmental Monitoring and Support Laboratory, U.S. EPA, Cincinnati, Ohio 45268, for use as check standards.

VI. Available Kits

There are a number of kits available and the reagent can be purchased with each one. Always use the same reagent from the company which developed the standards (wheel or sealed vials). With the reagent being a powdered mixture, the proportions or the components themselves may vary. Always check the kit against a calibration standard of potassium permanganate when a new batch of reagent is used. The companies listed below are those known at the time of preparation of this material and should not be considered as complete or as an endorsement.

Company	Kit No.	Reagent No.	Remarks
Hach Chemical Co.	CN-66 (2231-01)	14077-99	Includes comparator and 50 pillows.
Hellige* (Fisher Chem. Co.)	15-398-101C (disc only)	15-398-102A	Needs comparator (15-398-100D).
LaMotte Chem. Co.	LP-1 (6901)	6999-HS	Includes comparator and 50 tablets.
LoviBond	112A		Includes comparator and 50 tablets.

*This item is supplied through many chemical supply catalogs; the numbers supplied here represent those in the Fisher catalog.

The reagents listed are those to determine the free chlorine only. Additional reagents are available to determine combined and total chlorine. Most of the reagents are packaged in some form (tablet or powder) and contain enough reagent to carry out 50 determinations.

VII. Summary

The National Interim Primary Drinking Water Regulations permit the substitution of free residual chlorine analysis for up to 75% of the bacteriological analysis required of a water supply. When a State is named as the primary agency for carrying out the requirements of the Safe Drinking Water Act, it must give its approval and set limits for substitution. There are several points which should be specified by the State before granting permission to substitute, and these are:

A. The number and location of samples for which chlorine residuals are to be substituted.
B. The form and concentration of chlorine residual to be maintained.
C. The frequency of chlorine residual determinations; and
D. The analytical method to be used.

The Primary Regulations require that four residual chlorine determinations be carried out for each bacteriological analysis substituted and that the level of free chlorine be maintained at that not less than 0.2 mg/liter throughout the distribution system. The minimum of sampling frequency should be at least daily. It also suggests that the kit form of the DPD method be used for analysis.

References:

1. Federal Register, Part IV, December 24, 1975, National Interim Primary Drinking Water Regulations; pages 59566-59574.

2. Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971, APHA, AWWA, WPCF;1015 18th St. N.W., Washington, DC 20036.

3. Quality Criteria for Water, 1976 ed. USEPA, Washington, DC 20460.

4. Chemistry and Control of Modern Chlorination, A.T. Palin, June 1973, LaMotte Chemical Products Company, Chestertown, Maryland 21620.

APPENDIX

Addresses of companies mentioned in the text:

Hach Chemical Co.
713 South Duff Ave.
PO Box 907
Ames, IA 50010

Hellige: Available from many laboratory supply catalogs.
Example: Fisher Scientific Co.
1600 West Glenlake Ave.
Itasca, IL 60143

LaMotte Chemical Co.
Chestertown, MD 21620

LoviBond
Tintometer Ltd.
Waterloo Rd.
Salisbury, England

or in the U.S. - AKE Laboratory, Inc.
PO Box 46237
503 Broadway
Bedford, OH 44146

This outline was prepared by: J.D. Pfaff, Chemist, National Training and Operational Technology Center, MOTD, OWPO, USEPA, Cincinnati, OH 45268

Analysis for Turbidity in Drinking Water

I. Introduction

The National Interim Primary Drinking Water Regulations specify a maximum contaminant level (MCL) for a number of parameters. These parameters were chosen because of their health oriented effects on the consumer of the potable water. One of these parameters is turbidity. The regulations cite that several studies have demonstrated that the presence of particulate matter in water interferes with effective disinfection. Thus, water containing turbidity can contain pathogenic organisms even though it has been treated with chlorine as a disinfecting agent.

Turbidity has been monitored for many years in water treatment plants as an indicator of the efficiency of the treatment techniques of coagulation, flocculation and filtration. Evidence of turbidity after filtration gives an indication of breakthrough of floc into the finished water and showed the need for filter backwash and/or the possible improper operation of the flocculation-clarification procedure.

One of the earlier methods for the measurement of turbidity was the Jackson Candle turbidimeter which utilized a calibrated glass tube into which the sample was poured. When the image of the flame of a candle situated beneath the tube could no longer be distinguished, the tube was read and that was the turbidity of the sample. The main drawback of the Jackson turbidimeter was that its lower limit of measurement was 25 turbidity units referred to as Jackson turbidity units (JTU's).

II. Basic Principal

It should be emphasized from the beginning that turbidity is an optical property. Basically, turbidity is caused by the presence of suspended matter in water. Substances producing turbidity are usually inorganic in nature, however, finely divided organic matters such as plankton and other microscopic organisms can also produce turbidity. The particles producing turbidity may be further classified according to their size which may range from molecular dimensions to about 50 microns or larger. The fraction greater than one micron in diameter is generally referred to as silt and will settle out on standing. The smaller size particles can remain suspended for very long times.

It is these suspended particles that cause light to be scattered rather than transmitted in straight lines through the sample. The Jackson Candle turbidimeter measured transmitted light and it was not displaced as the standard method until the selection of the nephelometric method. This nephelometric method was adopted as the standard method in the 13th edition of Standard Methods for tne Examination of Water and Wastewater, and was also included in the 1969 edition of the FWPCA Methods for Chemical Analysis of Water and Wastes.

This method measures the light scattered by the particles in the sample at a ninety degree angle from the path of the incident light. The method is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference solution. Standardization of the design characteristics of the optical instruments and the material used to standardize the instruments are important requirements for accuracy of results.

III. Instrument Design - Nephelometer

Since the design of the instrument would affect the reading and consequently produce a variety of readings for even a standard solution, some design criteria had to be adopted. "Standard Methods" listed several criteria in an effort to standardize instrument design and use, and these were:

A. Light Source: Tungsten, operated at not less than 85% of rated voltage nor more than its rated voltage.

B. Photoelectric Detector: One or more with a read-out device, accept little to no stray light, free from significant drift after short warm-up, centered at 90°, accepts no light exceeding $\pm$ 30° from 90°.

C. Sensitivity: Maximum turbidity to be measured is 40 units, measure 0 to 40 units (several scales), detect differences of 0.02 units in waters of 1 unit.

D. Sample Tubes: Clear colorless glass, should be kept clean inside and out, free from scratches (discard when scratched or etched); do not handle where light strikes.

Some of these design criteria are shown in Figure 1. However a variation of this design that is acceptable is to have the light enter the side of the tube and be measured at a 90° angle again through the side of the cell. This allows the use of more than one detector all at 90° from the path of incident light.

Light from the lamp passes through a lens providing parallel rays which strike turbidity particles and scatter in all directions. Only those scattered at 90° to the path of the incident light are measured by the light sensor. The light sensor converts the light energy to electrical energy which is displayed on the meter. Stray light and transmitted light are absorbed by the walls of the instrument or some form of a light trap.

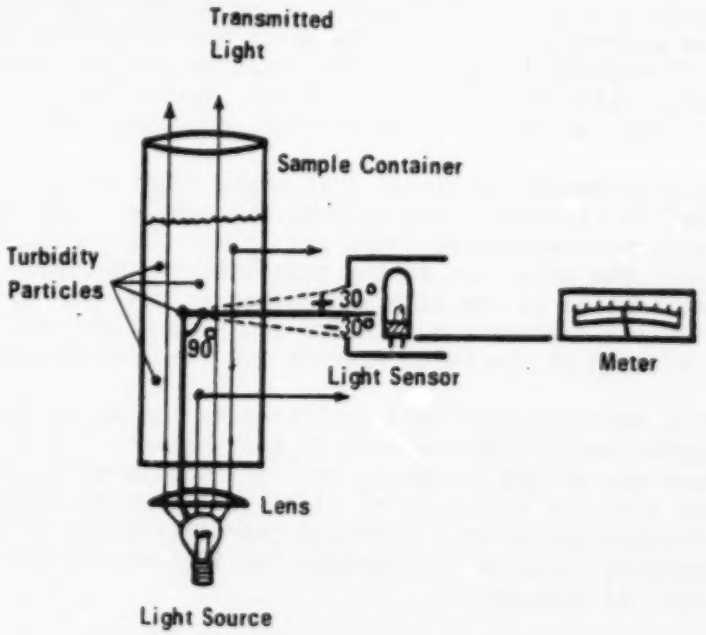

Figure 1.

IV. Factors Affecting Trubidity Readings

A. Interferences

Turbidity can be analyzed for any water that is free from debris and rapidly settling coarse materials. When collecting samples for turbidimetric measurements, care should be taken not to collect materials such as small strands of algae, sticks and coarse gritty materials. These can affect the readings by settling out over the bottom of the cell to block the light or by repeatedly passing through the light beam and resulting in erratic readings.

If the water is colored from dissolved solids, these can interfere by absorbing light and causing a low turbidity value.

Fine bubbles can form and collect on the sides of the sample tube, causing increased scattering of light and consequently a higher value. The bubbles can be detached from the cell wall by flicking the tube lightly with the finger and allowing the bubbles to rise to the surface. Very light shaking of the tube may also help to remove the bubbles.

Condensation of moisture on the sample tube is another item that can produce a low reading by blocking the light path. This happens when cold water samples are brought inside to warmer areas. Moisture can also form within the turbidimeter itself if it has been stored in a colder environment. Allow both sample and instrument to come to room temperature before attempting to take a reading.

The condition of the sample tube itself can cause incorrect readings. Scratches or any etching will scatter light, leading to higher readings. Finger prints or dirty tubes can cause low readings by blocking or absorbing light. The sample tubes should be handled only on areas which do not contact the light beam. The tubes should be kept clean and discarded if they become scratched or etched.

Stray light reaching the detector can cause significantly higher readings. Usually the inside of the cell compartment and the cover of the cell compartment are blackened by the manufacturer. This is done to absorb all scattered and/or transmitted light. Scratching the surface and exposing shiny metallic areas should be avoided. The sample cell condition, i.e., is it scratched, will also create stray light. Consequently, the instrument should be designed so that little stray light reaches the detector when there is no turbidity.

After the instrument has been allowed to warm up, it should be stable and have little drift. Some manufacturers specify that the instrument be left on if it is in regular use. Phototubes (detectors) can absorb moisture and will be slightly unstable when first turned on until this moisture has been driven off by the heat of the operating tube. Follow the manufacturer's directions for warm up as closely as possible.

One last source of error can be the standards themselves. Manufacturer's standards, usually provided with the instrument or at least available as an optional item, are secondary standards and should be monitored with

the primary standard, formazin, to check for deterioration. When formazin is prepared, only the stock is stable for longer than one week. Consequently, the age of the standards must be watched closely. The quality of the water used to dilute the formazin stock must be turbidity free.

In order to determine if the dilution water is turbidity free, first pass it through a membrane filter having a pore size no greater than 100 µm. It is best to begin with distilled water as the filter will clog rapidly with any other water. The membrane used in microbiological work can be used. If water so filtered shows a lower turbidity than the starting product the filtration should become routine or a new source of water sought. Usually the first 200 ml of filtered water is discarded in case the filter itself has any small materials in the pores. If there is no difference between the filtered and unfiltered waters the filtration step can be omitted. The filtration step should be done periodically, particularly if the source of water changes, to check for any changes in the quality of the water.

B. Meter Units

The early measurements of turbidity were done on the Jackson turbidimeter. Consequently, over the years much data have been accumulated in the Jackson units (JTU's). With the acceptance of the nephelometer as the standard measuring device nephelometric turbidity units (NTU's) came into use. When standardization of the nephelometer with the formazin polymer became mandatory, formazin turbidity units (FTU's) came about. And finally the National Interim Primary Drinking Water Regulations express the limits in turbidity units (TU's).

Since there is no direct relationship between the intensity of light scattered at 90° and the Jackson turbidity, there is no valid basis for the practice of calibrating a nephelometer in terms of JTU's. However, the turbidity of a given concentration of formazin suspension is defined as 40 units. This same suspension of formazin has an approximate turbidity of 40 JTU's when measured on the Jackson Candle turbidimeter, therefore, nephelometric turbidity units based on formazin will approximate units derived from the Jackson turbidimeter, but will not be identical to them.

The EPA "Manual of Methods for Chemical Analysis of Water and Wastes," 1974, states, "NTU's are considered comparable to the previously reported formazin turbidity units (FTU's) and Jackson turbidity units (JTU's)." Most instruments now in use are calibrated in NTU's.

A calibrated curve should be prepared for each range of the instrument by using a series of dilutions of the standard formazin turbidity suspension.

Each manufacturer of turbidimeters chooses the scales and range of his instrument. As mentioned, a sample turbidity above 40 units should not be read directly without dilution. Since the turbidity of the raw water is not required to be monitored to comply with the regulations, its turbidity may be read directly unless its reading is above the instruments highest scale. If this is the case, the analyst can dilute the sample until its reading can be obtained and then multiply his answer by the dilution factor.

The following formula may be used for the dilution calculation:

$$\text{Turbidity of the undiluted sample} = \frac{\text{Turbidity Reading} \times (V_s + V_d)}{V_s}$$

Where: V_s = volume of sample used (ml)

V_d = volume of dilution water used (ml)

Turbidity Reading = turbidity reading of the diluted sample

Because many treatment plants regularly monitor their raw water, turbidity instruments will usually read at least 100 turbidity units, with the lower scale reading in tenths of a turbidity unit. The purchaser of a turbidimeter should assure themselves of sufficient range to meet their needs.

V. Standardization

A. Historical

Over the years a variety of materials have been used to standardize the instrument. It has been one of the more perplexing problems connected with the measurement of turbidity to find a standard which was reproducible when made by different analysts. A standard must be uniform in particle size, number, shape and surface area, all parameters which would affect the turbidity value. Some of the materials used over the years were:

- Naturally turbid waters (clays)
  Diatomaceous earth
  Fullers earth
  Kaolin
  Barium sulfate
  Ground glass
  Silica

B. Present Standard

For various reasons, mostly, however, the lack of reproducibility, these materials fell from use. The formazin polymer, which gained acceptance as the turbidity standard reference suspension in the brewing industry, is now used as the reference turbidity standard for water. It is easy to prepare and is more reproducible in its light scattering properties than any of the others previously used.

The stock turbidity suspension (formazin) is produced by reacting given weights of hydrazine sulfate ($(NH_2)_2 \cdot H_2SO_4$) and hexamethylenetetramine ($(CH_2)_6N_4$) in distilled water, and allowing the mixture to stand for 24 hours at 25 ± 3°C. Any diltuions of the stock should be made up weekly. When the stock is diluted by a one to ten factor, a standard suspension defined as 40 NTU is obtained. Exact directions for producing the stock and standard suspension can be found in references one and two or in the laboratory section in this manual.

C. Stocks Commercially Available (Addresses in Appendix)

The stock turbidity standard can be purchased or prepared. The following list, while not complete, serves as an example of available materials.

The dry chemicals can be purchased from various companies in different grades and amounts. The analyst should purchase small amounts of the best grade available, usually an ACS, reagent or analyzed grade. Both the starting materials (hydrazine sulfate or hexamethylenetetramine) can be purchased from these companies:

Company	Hexamethylenetetramine Catalog No.	Hydrazine Sulfate Catalog No.
J.T. Baker Co.	N145	2177
Fisher Scientific Co.	H289	H320
MC/B-Sargent-Welch	HX-0280	HX-0575
A.H. Thomas	C-389	C-393
Hach Chemical Co.	1878-34	742-26

The Sargent-Welch Scientific Company provides the two chemicals in solutions which can be used to prepare the stock. They may be purchased in one pint quantities as Stock Trubidity Solution I-hydrazine sulfate (SC-17345) and Stock Turbidity Solution II-hexamethylenetetramine (SC-17346).

The Hach Chemical Company provides one pint quantities of a formazin stock solution of 4,000 NTU's (2461-11) from which dilutions can be made.

Fisher Scientific Company in conjunction with the HF turbidimeters provides a service which delivers by courier at three week intervals a kit which contains three ampoules of 400 NTU stock already prepared and three bottles of turbidity free water for dilution purposes (15-393-3).

All the aforementioned materials are used to prepare the primary formazin standard which should be considered as separate from the secondary standards that are available from all companies which produce turbidimeters. These secondary standards are sealed in vials and can be used to standardize the instruments. The document used to set down the criteria for certification of laboratories doing analysis for compliance with the NIPDWR suggests the following: "Sealed liquid turbidity standards purchased from the instrument manufacturers must be calibrated against properly prepared and diluted formazin standards at least every four months in order to monitor their eventual deterioration," and continues to say, "These standards should be replaced when any major change from the previous calibration occurs. Solid turbidity standards composed of plastic, glass or other materials are not reliable and should not be used."

When an instrument is to be calibrated, the analyst should at least calibrate the range to be used, and preferably all ranges of the instrument. The instrument should not be calibrated on a higher scale alone, when a lower scale is to be used. Most instruments are calibrated at the factory, however, a number of things can cause the instrument to lose its calibration. Consequently, the instruments calibration should be checked prior to its use. The secondary standards may be used, if monitored, to check the calibration of the ranges.

VI. Available Instrumentation

There are a number of instruments that meet the specifications as published in the references included in the NIPDWR. Each company may have a number of models that differ, for example, battery powered or line operated, etc. The companies listed below are those companies known at the time of preparation of this material and should not be construed as complete or as an endorsement. The user of a turbidimeter should contact any or all companies to find out what is available and their costs and specifications.

Bausch and Lomb (B&L) - attachment to the Spectronic mini 20 spectrophotometer - also available from chemical supply catalogs
Hach Chemical Company
HIAC Instruments
Hydroflow Inst. (HF) - Fisher Scientific Company
Monitec
Resource Technology
Sargent-Welch
Turner Designs
(See appendix for addresses.)

VII. Reporting Results

Both the standard references, 1 and 2 at the end of this unit, cover reporting by listing the extent to which the number should be carried. Report turbidity readings in accordance with the following schedule:

Turbidity Range in NTU's	Record to the Nearest
0 - 1.0	0.05
1 - 10	0.1
10 - 40	1
40 - 100	5
100 - 400	10
400 -1000	
>1000	100

VIII. Summary

In order to comply with the regulations set down in the National Interim Primary Drinking Water Regulations, a water treatment plant must monitor its supply at least daily for turbidity. In an effort at standardizing analytical results, the Nephelometric method as covered in the 13th edition of Standard Methods for the Examination of Water and Wastewater, APHA, pp. 350-353, and Methods for Chemical Analysis of Water and Wastes, EPA, pp. 295-298, has been chosen.

This nephelometric method measures the light scattered, by suspended particles in the sample, at right angles (90°) from the path of incident light. The higher the intensity of scattered light, the higher the turbidity. The instrument used to do this has been standardized by including certain design criteria which must be followed.

Another variable which has been standardized is the material used to calibrate the instrument. The adopted standard, a formazin polymer suspension, is prepared in a single operation or may be purchased in various forms from manufacturers of the turbidimetric instrumentation and/or chemical supply companies.

The actual measurement is to be carried out as soon as possible after sampling. Because of this regulation, the actual analysis may be carried out by anyone acceptable to the authority, State or Federal region. In all probability this will be the plant operator. The authority should make some effort to train or otherwise assure itself of the capability of the individual to carry out the analysis.

References:

1. Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971, APHA, AWWA, WPCF, 1015 18th St., N.W., Washington, DC 20036.

2. Manual of Chemical Analysis of Water and Wastes, 1974, USEPA, Technology Transfer, Cincinnati, Ohio 45268.

3. Manual for the Interim Certification of Laboratories Involved in Analyzing Public Drinking Water Supplies, September 1977, USEPA, the Water Supply Quality Assurance Group, Washington, DC 20460.

4. The National Interim Primary Drinking Water Regulations. Federal Register, Part IV, Vol. 40, No. 248, December 24, 1975, pp. 59566-59574.

This outline was prepared by J.D. Pfaff, Chemist, National Training and Operational Technology Center, MOTD, OWPO, USEPA, Cincinnati, OH 45268

APPENDIX

Addresses of the companies mentioned in the text:

J.T. Baker Chemical Co.
222 Red School Lane
Phillipsburg, NJ 08865

Baush and Lomb
820 Linden Ave.
Rochester, NY 14625
(Instruments manufactured by B&L can be pruchased from Fisher, Thomas and others.)

Fisher Scientific Co.
1600 W. Glenlake Ave.
P.O. Box 171
Itasca, IL 60143

Hach Chemical Co.
713 Duff Ave.
P.O. Box 907
Ames, IA 50010

H.F. Instruments, Ltd.
105 Healey Rd.
Bolton, Ontario, Canada
(Sold by Fisher Scientific Co.)

HIAC Instruments Division
Pacific Scientific
P.O. Box 3007
4719 W. Brooks St.
Montclair, CA 91763

MC/B Manufacturing Chemists
2909 Highland Ave.
Norwood, OH 45212

Monitec-Monitor Technology, Inc.
303 Convention Way
Redwood City, CA 94063

Resource Technology
P.O. Box 13452
University Station
Gainesville, FL 32604

Sargent-Welch Scientific Co.
10400 Taconic Terr.
Cincinnati, OH 45215

A.H. Thomas Co.
Vine Street at 3rd.
Philadelphia, PA 19106

Turner Designs
2247A Old Middlefield Way
Mountain View, CA 94043

Laboratory Procedure: Calibration and Use of a DPD Kit

I. Introduction

This procedure is basically to calibrate a kit against potassium permanganate and to determine the free chlorine in a water sample. It should be pointed out here that this procedure is applicable for drinking water analysis only not for wastewaters. Wastewaters may use the DPD method, but not in the kit form.

The suggestion to calibrate the visual standards, color wheel or sealed vials, comes in the document being used as criteria for certification of laboratories doing analysis of drinking waters. The reasoning behind the calibration is that the standards can fade or discolor and the color produced in the sample can vary with different batches of reagents. Consequently, a calibration and checking program is suggested to be carried out at intervals of every six months for the standards and each time a new batch of reagent is used.

The sample taken to be analyzed for free chlorine should be run as soon as possible or within one hour. It may not be preserved. Also, due to the number and location of samples being taken, the test will most probably be carried out in the field by the sampler. Consequently, the kit form was allowed.

II. Reagents

The reagent, N, N-diethyl-p-phenylenediamine and the phosphate buffer are best used as prepared by the manufacturer of the kit being used. Consequently, purchase of the combined reagent is recommended and the preparation will not be covered here. See the references for directions if needed.

A. Stock potassium permanganate solution

Weigh out 8.91 grams of potassium permanganate ($KMnO_4$). Transfer this to a 1000 ml volumetric flask. Add about 500 ml of distilled water and stir until dissolved. Add distilled water to the mark.

The weight of the potassium permanganate has been increased tenfold to allow the use of a nonanalytical balance. This will allow purchase of a balance for the treatment plant with sufficient accuracy to prepare the solution for under seventy dollars ($70).

B. Intermediate potassium permanganate solution

Add about 50 ml of distilled water to a 100 ml volumetric flask. Transfer with a volumetric pipet, 1.0 ml of the stock potassium permanganate solution into the 100 ml volumetric flask. Swirl until mixed. Add distilled water to the mark.

C. Standard potassium permanganate solution

Add about 50 ml of distilled water to a 100 ml volumetric flask. Transfer with a volumetric pipet 10 ml of the intermediate potassium permanganate solution into the 100 ml volumetric flask. Swirl until mixed. Add distilled water to the mark.

D. Dilution series for calibration of the manufacturer's standards

Prepare the standards calibration series to cover the range of the manufacturer's standards in your kit. Use the table below. Prepare the solutions in 100 ml volumetric flasks. Dilute with distilled water.

ml of Standard $KMnO_4$	ml of Water	Concentration Cl mg/l
0.0	100	0.0
2.0	98	0.2
4.0	96	0.4
6.0	94	0.6
8.0	92	0.8
10.0	90	1.0
15.0	85	1.5
20.0	80	2.0
30.0	70	3.0

III. Instrument Preparation

The sample containers should be kept clean by rinsing with distilled water. Occasional cleaning with a detergent and rinsing with tap and finally with distilled water should be done. The tubes should be handled near the top to prevent smudging the area where viewing takes place. Wipe the tube with a soft tissue before placing it into the comparator.

Check to see that the proper disk has been inserted in the comparator if this is the type in use. It is possible to use this comparator for different analysis by replacing the disk.

The prepared reagents usually are purchased in lots of 50. Depending on the number of chlorine determinations that must be carried out, larger numbers of reagent packets should be purchased. This will prevent running out in the middle of a series of samples and will necessitate less checking.

IV. Instrument Standardization

This entire procedure should be carried out upon receipt of the color wheel or block and standards. This will then calibrate these standards and thereafter this procedure should be carried out about every 6 months. One or two potassium permanganate solutions should be made and used when new batches of reagents are used to see if the same amount of color is produced as was with the old reagent. Follow the steps below.

A. Calibration of visual standards

1. Prepare a series of potassium permanganate solutions that will cover the entire range of the manufacturer's standards.

2. Rinse the sample container with the least concentrated solution. If two containers are used, rinse both.

3. Fill the tube to the mark with the least concentrated solution. If two sample containers are used in your type kit, fill both.

4. If two tubes are used for each sample analysis (Hach, Hellige), cap one tube, wipe clean with soft tissue and insert into the blank position of the comparator. This is usually the left hand position.

5. Add the reagent (one tablet or the contents of one powder container) to the sample tube.

6. Cap and mix well. Not all reagent must dissolve to produce a correct value.

7. Insert into comparator.

8. Hold comparator up to the light (window, lamp, sky, etc.).

9. Match standard color with sample color.

10. Carry out steps 6-9 within one minute.

11. Record reading, i.e., which manufacturer's standard matches the color in the tube.

12. Remove sample container(s).

13. Repeat steps 2-11 using all other prepared potassium permanganate solutions, working from low to high concentrations and recording all readings.

    These readings should be recorded in a permanent manner (in ink in a bound notebook) and dated. They may be plotted if desired. Future calibrations can be compared to past readings to check on deterioration of standards.

    If other determinations such as combined or total chlorine are to be carried out, check the directions of the manufacturer.

B. Check of New Reagent

1. Choose two of the concentrations of potassium permanganate which were used to calibrate the visual standards (Section IV.A, Step 1).

2. Prepare these solutions (Table on Page E4-2).

3. Carry out steps 2-11 (IV.A) for each.

4. If the same values are obtained, proceed with sample analysis.

5. If the same values are not obtained, prepare the rest of the potassium permanganate solutions and re-calibrate (IV.A).

6. Record new values, date, and if available, lot number of reagent (found on reagent package) in the same place as old values were recorded.

V. Sample Analysis

If colors are produced in the sample that exceed the highest standard, dilute the sample with distilled water. Diluting in half, i.e., one volume of sample and one volume of distilled water, should provide sufficient dilution. Mix the reagent (powder or tablet) with the distilled water before adding the sample. This way any interference in the distilled water will react with the reagent before decreasing the amount of free available chlorine. Multiply the reading obtained by 2 if diluted in half.

Be sure to fill the sample tubes to the marks provided. The mixture and amount of reagents are dependent upon this volume.

With some comparators, an estimated value may have to be made if there is no exact color match. To do this, find a color that is weaker and one that is stronger than the sample color and report the middle value.

To determine the sample value proceed by carrying out the following steps:

1. Rinse the tube(s) with the sample three times.
2. Fill the tube(s) to the mark with the sample.
3. Wipe the tube(s) with a soft tissue.
4. Add the reagent to only one tube.
5. Cap and mix to dissolve (not all reagent must dissolve to produce the correct value).
6. Insert the tube with the reagent into the comparator (usually the right-hand opening in those comparators using two sample containers). The tube without the reagent is inserted in the left hand opening (consult manufacturer's directions).
7. Hold comparator up to the light (window, lamp, etc.).
8. Make reading within one minute (steps 4-8).
9. Record the matching or intermediate reading.
10. Remove sample containers and rinse with distilled water or next sample. Be sure any excess reagent from the previous run is removed.

VI. Instrument Care

The comparator is easily cared for. Keep it clean (wiping off dust). This is best done by keeping it in its box. Keep the visual standards (color wheel or ampules) out of direct sunlight and prevent physical abuse.

Should the visual standards be broken, or differ significantly from the potassium permanganate solution values (in the calibration steps) purchase a new set of standards.

If the color wheels are switched with others, for example pH, protect those not in the comparator by keeping them in their original container and out of direct sunlight.

VII. Summary

This outline was prepared to cover the determination of free chlorine in drinking water supplies by the "Kit" form of the DPD test. Calibration of the manufacturer's visual standards should be carried out every 6 months to monitor deterioration of the standards. New batches of reagents should be checked against two of the same standards, used for calibration, prior to use on samples.

The "Kits" can determine other forms of chlorine but these procedures are not given here because they are not required to be measured as is the free form.

References:

1. Standard Methods for the Examination of Water and Wastewater, 13th and 14th editions, 1971 and 1975, APHA, AWWA, WPCF, 1015 18th St., NW, Washington, DC 20036.

2. Manual of Chemical Analysis of Water and Wastes, 1974, USEPA, Technology Transfer, Cincinnati, Ohio 45268.

3. Manual for the Interim Certification of Laboratories Involved in Analyzing Public Drinking Water Supplies, September 1977, USEPA, The Water Supply Quality Assurance Work Group, Washington, DC 20460.

This outline was prepared by J.D. Pfaff, Chemist, National Training and Operational Technology Center, MOTD, OWPO, USEPA, Cincinnati, OH 45268

Laboratory Procedure: Calibration and Use of a Nephelometric Turbidimeter

I. Introduction

The following procedures include the preparation and calibration of the Formazin standard as well as the directions for the use of the turbidimeter. It should be pointed out that the manufacturer's sealed ampules are not formazin, but have been standardized against formazin. This makes them secondary standards. In addition, they will not remain stable indefinitely and should be monitored against formazin standards regularly to check for deterioration. They should be checked at the minimum every four months; more often would be preferable. The dates on which they are monitored and their values should be recorded to give evidence of the regularity of monitoring as well as to provide evidence of when they deteriorated.

Not all sections need to be done and the analyst should read the entire procedure and determine which sections apply to his circumstances.

II. Reagents

A. Turbidity Free Water

Determine the turbidity value of the distilled water before and after filtering it through a membrane filter having a pore size no greater than 100 µm (the filter used in bacteriological work can be used). Discard the first 200 ml of filtered water. If the turbidity is lower, use the filtered water, otherwise use the distilled water. The water with the lower turbidity should be used to make up all standards and dilutions. Prepare fresh for each preparation of standards.

B. Stock Turbidity Suspension (400 TU's)

1. From dry chemicals: Dry chemical should be discarded if caking or discolorization occurs or if standards prepared from the chemicals do not compare with previous ones.

   a. Solution 1 - Dissolve 1.00 gram of hydrazine sulfate, $(NH_2)_2 \cdot H_2SO_4$, in turbidity free water and dilute to 100 ml with turbidity free water, in a volumetric flask. The chemical can be weighed on a balance that has 0.01 gram sensitivity.

   b. Solution 2 - Dissolve 10.00 grams of hexamethylenetetramine $(CH_2)_6N_4$ in turbidity free water and dilute to 100 ml with turbidity free water in a volumetric flask. The chemical can be weighed on a balance that has 0.01 gram sensitivity.

   c. Suspension 1- Add 5.0 ml of solution 1 and 5.0 ml of solution 2 to a 100 ml volumetric flask. Mix, allow to stand 24 hours at 25 $\pm$3°C, then dilute, with turbidity free water to 100 ml and mix. The turbidity of the suspension is 400 units. Prepare the solutions and suspension fresh monthly.

2. From solutions: As purchased, for example from Sargent-Welch.

   Suspension 1 - Add 5.0 ml of solution 1 (1% hydrazine sulfate) and 5.0 ml of solution 2 (10% hexamethylenetetramine) to a 100 ml volumetric flask. Mix, allow to stand 24 hours at 25 + 3°C, then dilute with turbidity free water to 100 ml and mix. The turbidity of this suspension is 400 units. Purchase solutions fresh monthly, prepare suspension fresh monthly.

3. From suspension: As purchased, for example from Hach

   Suspension 1 - Add 10.0 ml of the purchased stock (4000 units) to a 100 ml volumetric flask. Dilute, with turbidity free water to 100 ml and mix. The turbidity of this suspension is 400 units. Purchase stock and prepare suspension fresh monthly.

C. Dilutions

Prepare a dilution of stock standard (400 units) for each scale of the turbidimeter. Since the number of scales on each instrument may vary, make only those needed from the table below. Prepare in labeled 100 ml volumetric flasks, pipet with volumetric pipets.

Dilution Number	ml to Add	ml of Water*	Turb. (TU's)	Calibration of Range
Stock	100 ml	-	400	0-1000
1	10 ml Stock	90	40	0-100
2	10 ml Dil. 1	90	4	0-10
3	10 ml Dil. 2	90	0.4	0-1
4	10 ml Dil. 3	90	0.04	0-0.1

*Use turbidity free water for all dilutions.

Prepare all dilutions fresh weekly.

III. Instrument Preparation

A. Warm-up

Follow manufacturer's directions for warm-up. Set instrument on highest scale between readings. Turn off only if instrument is not to be used for longer periods of time. Line operated instrument can be left on all day if use warrants it. Battery operated should be turned off to conserve batteries, if no runs are to be made for reasonable (about one-half hour) intervals of time.

B. Sample Tube Cleaning

Sample tubes to be used with the available instrument should be kept scrupulously clean. If raw water is analyzed and any grease or oil is present, organic solvents such as alcohol or acetone should be used to remove any oily residues. Otherwise the tubes may be rinsed with turbidity free water. Cleaning the tubes with detergent should be done only when necessary in order to prevent the possibility of scratching the tubes with the brush and/or the detergent. Tubes should be discarded when they become scratched or etched.

C. Scale

If an insert card is used as the scale of the meter, check to see that it is properly positioned.

IV. Instrument Standardization

A. Initial Instrument Calibration and Secondary Standard Check

1. Prepare about 1 liter (about 1 quart) of turbidity free water by filtering distilled water through a membrane filter. See Section II.A. Prepare any additional amount fresh as needed.

2. Prepare or purchase a stock formazin suspension (400 TU's), See Section II.B. The stock should not be over 1 month old.

3. Prepare a series of dilutions of the stock formazin suspension. See Section II.C. Use turbidity free water for all dilutions. Prepare a dilute suspension that can be read near mid-scale for each range on your instrument.

4. Turn on instrument, and allow sufficient time for warm-up. Follow manufacturer's directions.

5. Check instrument sample cells for cleanliness.

6. Set instrument on highest range.

7. Fill cell with most concentrated suspension prepared in Step 3. Shake well.

8. Insert in cell compartment. Follow manufacturer's directions; a range adaptor or cell riser may have to be put in place with some instruments. Care should be taken to wipe the cell with a soft tissue to remove liquid and smudges from the outside of the cell. Always handle the cells near the top edge to prevent touching it in the area where the light will strike it. Place cap on cell before placing it in the cell compartment if it has a cap. Allow any bubbles to rise before placing cell in compartment. This may be facilitated by flicking it with a finger or inverting it (with capped cells). These precautions should be carried out in future steps where applicable. Cover the cell compartment with the light shield.

9. Adjust the reference adjust knob to set the reading of the meter scale to match the known value for the formazin standard.

10. If a sealed vial, secondary standard, from the manufacturer is available for this scale, remove the formazin and replace it with the secondary standard. Check manufacturer's directions as to shaking, usually secondary standards are not shaken. The secondary standard should read the value marked on the vial. If not, check the makeup of the formazin standard. If it has been prepared correctly and the secondary standard is relatively new, record the reading obtained when compared with the formazin standard.

11. Remove sample cell and discard formazin standard and rinse three times with turbidity free water, then three times with the second highest turbidity suspension.

12. Set the range selector on the next highest range. Check with manufacturer's directions regarding the use of range adaptor or cell riser use.

13. Fill cell with a standard that can be read near mid scale and place it it the cell compartment. Follow good cell handling techniques. See Step 8. Cover compartment with light shield.

14. Adjust reference adjust knob to set the scale reading to match the value of the formazin standard. Check any secondary standard available that can be read on this scale.

15. Proceed using the same steps (6 through 11) for all other scales of the meter. Note any discrepancies between formazin standards and secondary standards (manufacturer's sealed vials).

16. On instruments that allow adjustment of each range with an adjustment other than the reference adjustment knob, follow the manufacturer's directions and recalibrate each scale against the formazin standards as they are read if it is needed. Record the readings of all secondary standards and the date, after adjusting the meter against the formazin standard.

B. Daily Instrument Check

Just prior to use of the instrument it must be standardized. This can be done with the manufacturer's secondary standard. A standard should be used that will be in the range which the sample will be run on. In most potable water treatment plants this will be the 0 to 1 scale or possibly even a smaller scale. Most instrument manufacturers supply a standard in this range (i.e., a 0.12 mineral oil or 0.61 chlorobenezene). Provided this standard has been compared to a formazin standard upon receipt, and at least every 4 months thereafter, it can be used. This secondary standard should be discarded when it fails to give its proper reading against a formazin standard.

1. Turn on instrument and allow it to warm up. Follow manufacturer's directions.

2. Set instrument on a high scale.

3. Insert the secondary standard for the scale that will be used for the sample (i.e., 0.12 or 0.61) into the cell compartment. Wipe the container with a soft tissue. Avoid touching it where the light strikes it.

4. Cover with light shield.

5. Turn range selector to proper scale.

6. Allow meter needle to stabilize.

7. Adjust meter with the reference adjust knob to read value of standard. This value should be on the standard and should also be recorded in some type of log showing check value against a formazin standard and date checked.

8. Turn to high range.

9. Remove light shield.

10. Remove standard.

11. Replace light shield.

V. Sample Analysis

A. Samples above 40 Units

The references included in the National Interim Primary Drinking Water Regulations, Std. Methods and EPA Methods Manual, stipulate that the maximum turbidity to be measured is 40 units. The larger scales (0-1000) could be used to obtain some idea of the dilution necessary to bring the reading below 40. The sample value is then multiplied by the dilution factor. Be sure to have sufficient turbidity free water available to make dilutions and rinse sample cells.

1. Be sure the instrument is warmed up.

2. Rinse sample cell with the sample three times.

3. Fill cell about 3/4 full.

4. Put on cap (if sample container has one).

5. Wipe cell with soft tissue.

6. Set on highest range - follow manufacturer's directions - some instruments require the use of an insert for the higher ranges.

7. Remove light shield.

8. Insert sample cell.

9. Replace light shield.

10. Allow meter needle to stabilize.

11. Read turbidity value on the appropriate scale.

12. Remove light shield.

13. Remove cell.

14. Replace light shield.

15. Dilute the sample with one or more volumes of turbidity free water until the turbidity falls below 40 units.

16. Remove light shield.

17. Insert standard (chosen to be on the same range as sample will be read on).

18. Replace light shield.

19. Select proper range.

20. Allow meter to stabilize.

21. Adjust meter with reference adjust knob to read value of standard.

22. Turn range adjust to high range.

23. Remove light shield and standard from cell compartment.

24. Rinse sample cell three times with sample, then fill cell with sample and wipe cell with tissue.

25. Place cell into cell compartment and replace light shield.

26. Turn range adjust to proper range.

27. Allow meter to stabilize.

28. Read sample value.

29. Turn range adjust to high range and remove light shield and sample container.

30. Replace light shield.

31. Multiply value by the dilution factor (see section VII.A).

B. Samples below 40 Units

Before attempting any readings, check that the instrument is warmed up, cells are clean and sufficient turbidity free water is available to rinse cells. Always handle the cell(s) near the top and always wipe cell with a tissue just prior to insertion into cell compartment. Instructions are included to go to high ranges before removing the light shield, this is to protect the instrument's meter from damage. For samples below 40 units, which are all finished waters, steps 16 through 30 of section V.A should be followed.

VI. Instrument Care

When not in use, the instrument should be kept covered or closed in order to prevent dust from settling on the instrument. The instrument should be protected from extremes in temperature, moisture and dampness, and physical abuse.

Spare light sources, extra cells and fuses should be kept on hand so immediate replacement can be made in the event of failure or breakage.

Maintenance should be carried out by an instrument service man with the exception of replacement of the light source. For other things such as focusing the light source after replacement and cleaning the optical lenses etc., follow the instrument manufacturer's directions.

Store the cell clean and in a protected manner to avoid scratches and marking. Discard the sample cell when it becomes scratched or etched.

Protect all secondary standards, the manufacturer sealed glass ampules. Store away from temperature extremes, physical abuse and protect from direct sunlight.

VII. Reporting and Calculations

A. Calculations

If it is necessary to dilute the sample as in the case when the sample turbidity is above 40 units the following calculation can be used as the dilution factor:

$$TU = \frac{A \times B}{C}$$

Where TU = Turbidity Units of the sample before dilution
A = Turbidity Units of the sample after dilution
B = Volume (ml's) to which the sample was diluted
C = Volume (ml's) of the sample used for dilution.

Example = If 10 ml of sample was diluted to 100 ml and gave a reading of 20 TU, then

$$TU = \frac{A \times B}{C}$$

$$= \frac{20 \times 100}{10} = 200 \text{ TU's}$$

B. Reporting

Report values as follows:

TU's	Record to Nearest
0.0 - 1.0	0.05
1 - 10	0.1
10 - 40	1
40 - 100	5
100 - 400	10
400 - 1000	50
>1000	100

References:

1. Standard Methods for the Examination of Water and Wastewater, 13th and 14th editions, 1971, 1975, APHA, AWWA, WPCF, 1015 18th ST., NW, Washington, DC 20036.

2. Manual of Chemical Analysis of Water and Wastes, 1974, USEPA, Technology Transfer, Cincinnati, Ohio 45268.

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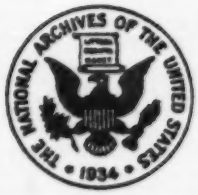
federal register

WEDNESDAY, DECEMBER 24, 1975



PART IV:

ENVIRONMENTAL PROTECTION AGENCY

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WATER PROGRAMS

National Interim Primary Drinking Water Regulations

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

SUBCHAPTER D—WATER PROGRAMS

[FRL 464-7]

PART 141—NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

On March 14, 1975, the Environmental Protection Agency (EPA) proposed National Interim Primary Drinking Water Regulations pursuant to sections 1412, 1414, 1415, and 1450 of the Public Health Service Act ("the Act"), as amended by the Safe Drinking Water Act ("SDWA," Pub. L. 93-523), 40 FR 11990. EPA held public hearings on the proposed regulations in Boston, Chicago, San Francisco, and Washington during the month of April. Several thousand pages of comments on the proposed regulations were received and evaluated. In addition, the Agency has received comments and information on the proposed regulations from the National Drinking Water Advisory Council, the Secretary of Health, Education, and Welfare, and from numerous others during meetings with representatives of State agencies, public interest groups and others.

The regulations deal only with the basic legal requirements. Descriptive material will be provided in a guidance manual for use by public water systems and the States.

The purpose of this preamble to the final regulations is to summarize the most significant changes made in the proposed regulations as a result of comments received and the further consideration of available information. A more detailed discussion of the comments and of changes in the proposed regulations is attached as Appendix A.

Water Systems Covered

The Safe Drinking Water Act applies to each "public water system," which is defined in Section 1401(4) of the Act as "a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals." Privately owned as well as publicly owned systems are covered. Service "to the public" is interpreted by EPA to include factories and private housing developments. (See generally, House Report, pp. 16-17.)

The definition of "public water system" proposed in the Interim Primary Drinking Water Regulations sought to explain the meaning of the statutory reference to "regular" service. It was proposed to interpret this term as including service for as much as three months during the year. Because the proposed definition would have excluded many large campgrounds, lodges, and other public accommodations which serve large numbers of tourists but which are open for slightly less than three months each year, the definition in the final version covers systems serving an average of at least twenty-five individuals at least 60 days out of the year. The use of a minimum number of days rather than months also makes clear that a system may qualify as a public water system even if it is not open every day during a given month.

Once "public water system" has been defined, it is necessary to define the two major types of public water systems—those serving residents and those serving transients or intermittent users. The possible health effects of a contaminant in drinking water in many cases are quite different for a person drinking the water for a long period of time than for a person drinking the water only briefly or intermittently. Different regulatory considerations may in some cases apply to systems which serve residents as opposed to systems which serve transients or intermittent users. Accordingly, § 141.2(e) makes clear that all "public water systems" fall within either the category of "community water systems" or the category of "non-community water systems." To make clear which regulatory requirements apply to which type of system, the category covered is specifically indicated throughout the regulations.

The proposed regulations defined a "community water system" as "a public water system which serves a population of which 70 percent or greater are residents." Reliance in the proposed definition on the percentage of water system users who are residents would result in treating some fairly large resort communities with many year-round residents as non-community systems. Therefore, the definition of "community water system" has been changed to cover any system which serves at least 15 service connections used by year-round residents or serves at least 25 year-round residents.

Small Community Water Systems

Many community water systems in the country are quite small. Since it is the intention of the Act to provide basically the same level of health protection to residents of small communities as to residents of large cities, and since a number of advanced water treatment techniques are made feasible only by economies of scale, the cost of compliance with the requirements of the Act may pose a serious problem for many small communities. The regulations seek to recognize the financial problems of small communities by requiring more realistic monitoring for systems serving fewer than 1,000 persons. Variances and exemptions authorized by the Act can also assist in dealing with economic problems of small community systems in appropriate cases, at least temporarily. EPA will provide technical assistance on effective treatment techniques which can be used by small systems.

These methods of dealing with the financial problems of some small community systems may not be sufficient in specific instances to make compliance with all applicable regulatory requirements feasible. EPA is commencing a study of potential problems faced by small community systems in meeting applicable requirements under the Act and these regulations, and, if necessary, will make additional adjustments in the Interim Primary Drinking Water Regulations prior to their effective date.

Non-Community Systems

"Non-community systems" are basically those systems which serve transients. They include hotels, motels, restaurants, campgrounds, service stations, and other public accommodations which have their own water system and which have at least 15 service connections or serve water to a daily average of at least 25 persons. Some schools, factories and churches are also included in this category. It is conservatively estimated that there are over 200,000 non-community water systems in the country. However, it should be recognized that while their number is large, they normally are not the principal source of water for the people they serve.

The regulations as proposed would have applied all maximum contaminant levels to non-community systems as well as to community systems. This approach failed to take into account the fact that the proposed maximum contaminant levels for organic chemicals and most inorganic chemicals were based on the potential health effects of long-term exposure. Those levels are not necessary to protect transients or intermittent users. Therefore, the final regulations provide that maximum contaminant levels for organic chemicals, and for inorganic chemicals other than nitrates, are not applicable to non-community systems. An exception was made for nitrates because they can have an adverse health effect on susceptible infants in a short period of time.

Even without monitoring for organic chemicals or most inorganic chemicals, in the initial stages of implementation of the drinking water regulations, monitoring results from tens of thousands of non-community systems could overwhelm laboratory capabilities and other resources. This could delay effective implementation of the regulations with respect to the community systems which provide the water which Americans drink every day. To avoid this result, non-community systems will be given two years after the effective date of the regulations to commence monitoring. In the meantime, non-community systems which already monitor their water are encouraged to continue to do so, and the States are encouraged to take appropriate measures to test or require monitoring for non-community systems that serve large numbers of people.

Of course, non-community systems which pose a threat to health should be dealt with as quickly as possible. The maximum contaminant levels applicable to non-community water systems therefore will take effect 18 months after promulgation, at the same time as levels applicable to community systems. Inspection and enforcement authority will apply to non-community systems at the same time as to community systems.

Sanitary Surveys

EPA encourages the States to conduct sanitary surveys on a systematic basis.

These on-site inspections of water systems are more effective in assuring safe water to the public than individual tests taken in the absence of sanitary surveys. The regulations provide that monitoring frequencies for coliform bacteria can be changed by the entity with primary enforcement responsibility for an individual non-community system, and in certain circumstances for an individual community system, based on the results of a sanitary survey.

Maximum Contaminant Levels

Numerous comments were received by EPA on the substances selected for the establishment of maximum contaminant levels and on the levels chosen. Congress anticipated that the initial Interim Primary Drinking Water Regulations would be based on the Public Health Service Standards of 1962, and this Congressional intent has been followed. Comments received on the various levels did not contain new data sufficient to require the establishment of levels different from those contained in the Public Health Service Standards.

Water Consumption

The maximum contaminant levels are based, directly or indirectly, on an assumed consumption of two liters of water per day. The same assumption was used in the 1962 Standards. This assumption has been challenged because of instances where much higher water consumption rates occur. EPA's justification for using the two-liter figure is that it already represents an above average water or water-based fluid intake. Moreover, while the factor of safety may be somewhat reduced when greater quantities of water are ingested, the maximum contaminant levels based on the two-liter figure provide substantial protection to virtually all consumers. If, as has been suggested, a water consumption rate of eight liters per day is used as the basis for maximum contaminant level, all of the proposed MCL's would have to be divided by four, greatly increasing the monitoring difficulties, and in some cases challenging the sensitivity of accepted analytical procedures. It could be expected, in such a case, that the maximum contaminant levels would be exceeded to a significant degree, and that specialized treatment techniques would be required to order that the contaminant levels would be reduced. The economic impact of a move in this direction would be enormous. It is not technically or economically feasible to base maximum contaminant levels on unusually high consumption rates.

Safety Factors

A question was raised about the fact that different safety factors are contained in various maximum contaminant levels. The levels are not intended to have a uniform safety factor, at least partly because the knowledge of and the nature of the health risks of the various contaminants vary widely. The levels set are the result of experience, evaluation of the available data, and professional judgment. They have withstood the test of time and of professional review. They are being subjected to further review by the National Academy of Sciences in connection with development of data for the Revised Primary Drinking Water Regulations.

MCL's Based on Temperature

A question was also raised as to whether ranges of maximum contaminant levels should be established on the basis of the climate in the area served by the public water system, as was done with fluoride. EPA believes that the use of a temperature scale for fluoride is more appropriate than for other chemicals because of the studies available on the fluoride-temperature relationship and because there is a small margin with fluoride between beneficial levels and levels that cause adverse health effects.

MCL's Deleted

Three proposed maximum contaminant levels have been eliminated in the final regulations because they are not justified by the available data. One of these is carbon chloroform extract (CCE), which is discussed separately below. The others are the proposed levels for the standard bacterial plate count and cyanide. In the case of the plate count, it is believed that the coliform limits contained in the regulations, combined with the turbidity maximum contaminant level, adequately deal with bacterial contamination. However, EPA continues to believe that the standard plate count is a valid indicator of bacteriological quality of drinking water, and recommends that it be used in appropriate cases in conjunction with the coliform tests as an operational tool.

The proposed maximum contaminant level for cyanide was eliminated because the possibility of cyanide contamination can be effectively addressed only by the use of emergency action, such as under Section 1431 of the Act. EPA's 1969 Community Water Supply Study did not reveal a single instance in which cyanide was present in a water system at a level greater than one-thousandth of the level at which cyanide is toxic to humans.

Available data indicate that cyanide will be present in water systems at toxic levels only in the event of an accident, such as a spill from a barge collision. Maximum contaminant levels are not the appropriate vehicle for dealing with such rare, accidental contamination.

Heptachor, heptachlor epoxide and chlordane have also been removed from the list of maximum contaminant levels at least temporarily in view of the pending cancellation and suspension proceedings under the Federal Insecticide, Fungicide and Rodenticide Act involving those pesticides. When the results of these proceedings are available, EPA will again consider whether maximum contaminant levels should be established for those three pesticides.

Sodium and Sulfates

A number of comments were received on the potential health effects of sodium and sulfates. The National Drinking Water Advisory Council has recommended that consideration be given to the monitoring of these constituents, but has not recommended the adoption of maximum contaminant levels because available data do not support the adoption of any specific levels. EPA has requested the National Academy of Sciences to include sodium and sulfates among the contaminants to be studied by NAS, and to include information on the health effects of sodium and sulfates in the report to be made by NAS in December 1976.

Since a number of persons suffer from diseases which are influenced by dietary sodium intake and since there are others who wish to restrict their sodium intake, it is desirable that the sodium content of drinking water be known. Those affected can, by knowing the sodium concentration in their drinking water, make adjustments to their diets or, in extreme cases, seek alternative sources of water to be used for drinking and food preparation. It is recommended that the States institute programs for regular monitoring of the sodium content of drinking water served to the public, and for informing physicians and consumers of the sodium concentration in drinking water.

A relatively high concentration of sulfate in drinking water has little or no known laxative effect on regular users of the water, but transients using such water sometimes experience a laxative effect. It is recommended that the States institute monitoring programs for sulfates, and that transients be notified if the sulfate content of the water is high. Such notification should include an assessment of the possible physiological effects of consumption of the water.

PCB's and Asbestos

An interagency comment expressed concern for asbestos and PCB's in the environment and noted the need for at least a monitoring requirement, if not for MCL's, for these contaminants. EPA is also concerned, but for the moment lacks sufficient evidence regarding analytical methods, health effects, or occurrence in the environment to establish MCL's. The Agency is conducting research and cooperating in research projects to develop criteria for establishing needed limits as quickly as possible. A monitoring study on a number of organic chemical contaminants, including PCB's, for which MCL's are not being established at this time, will be contained in an organic chemical monitoring regulation that is being promulgated with these regulations. Regarding asbestos, HEW and EPA are sponsoring a number of studies this year at an approximate cost of $16 million to establish health effects, anayitical methods and occurrence.

Point of Measurement

Other comments on maximum contaminant levels focused on the proposed requirement that such levels be tested at the consumer's tap. Concern was expressed over the inability of the public water system to control potential sources

of contaminants which are under the control of the consumer.

The promulgated definition of "maximum contaminant level," § 141.2(d), retains the requirement that the maximum contaminant level be measured at the tap except in the case of turbidity, which should be measured at the point of entry to the distribution system. However, the definition has been expanded to make clear that contaminants added to the water by circumstances under the control of the consumer are not the responsibility of the supplier of water, unless the contaminants result from corrosion of piping and plumbing resulting from the quality of the water supplied. It should be noted, however, that this requirement should not be interpreted as to discourage local, aggressive cross connection control measures.

Coliform Bacteria MCL's

The promulgated MCL's for coliform bacteria are basically the 1962 Public Health Service Standards, with minor refinements and clarifications. However, further changes may be desirable. For example, the MCL's for the membrane filter analytical method do not resolve the question of how many coliform bacteria are assumed to be present in a single highly contaminated sample. Some laboratories assume an upper limit of 50, while others seek to continue to count individual bacteria to a level of 100 or even higher in a single sample. The upper limit assumed will affect the monthly average which is calculated to determine compliance with the MCL's.

Another question relating to the coliform bacteria MCL's is the matter of possible spurious positive samples. As the regulations are written, all routine samples taken to determine compliance with the MCL's must be counted, regardless of the results of analysis of any check samples that may be taken. The reason for this is that bacterial contamination is often intermittent or transient, and as a result negative check samples taken a day or more after a positive sample cannot demonstrate that the positive result was in error. It may be possible, however, to prescribe a means of dealing with spurious positive results without compromising the integrity of the MCL's.

A third question concerning the MCL's for coliform bacteria is the relationship of monthly averages of coliform bacteria levels to monthly percentages of positive samples. For example, the monthly average MCL for the membrane filter method is violated if the monthly average exceeds one coliform bacterium per sample. However, for purposes of determining whether the monthly-percentage-of-positive-samples MCL is violated, a sample is counted as positive only if it contains more than four coliform bacteria. Thus, it is possible, particularly when a relatively small number of samples is taken, for a system to fail the monthly average MCL even when no single sample taken during the month is out of compliance with the limit.

These and other questions concerning the coliform bacteria MCL's will be reviewed further by EPA. If review indicates that changes in the MCL's are desirable, those changes will be made as soon as possible but within 6 months, in time to take effect at the same time as the initial Interim Primary Drinking Water Regulations.

Organic Chemicals

The proposed maximum contaminant levels for organic pesticides, other than the three which are the subject of cancellation and suspension proceedings, have been retained. It is anticipated that additional organic pesticides will be added to the regulations if surveys of pesticides in drinking water being conducted by EPA indicate that this is needed.

The proposed regulations also contained a maximum contaminant level for organic chemicals obtained by the carbon chloroform extract (CCE) method. It was anticipated by Congress that organic chemicals would be dealt with primarily in the Revised Primary Drinking Water Regulations because of the paucity of accurate data on the health effects of various organic chemicals, the large number of such chemicals, uncertainities over appropriate treatment techniques, and the need for additional information on the incidence of specific organic chemicals in drinking water supplies. EPA thought that the CCE standard might provide an appropriate means of dealing with organic chemicals as a class pending action on the Revised Primary Regulations.

The CCE standard was originally developed as a test for undesirable tastes and odors in drinking water. As concern developed over the health effects of organic chemicals, the possibility of using CCE as a health standard rather than an esthetic standard was considered.

As pointed out by numerous comments, CCE has many failings as an indicator of health effects of organic chemicals. To begin with, the test obtains information on only a fraction of the total amount of organic chemicals in the water sampled. Furthermore, there is serious question as to the reliability of CCE in identifying those organic chemicals which are most suspected of adverse health effects. In addition, there are no existing data on which a specific level for CCE can be established on a rational basis. To establish a maximum contaminant level under these circumstances would almost certainly do more harm than good. It could give a false sense of security to persons served by systems which are within the established level and a false sense of alarm to persons served by systems which exceed the level. It also would divert resources from efforts to find more effective ways of dealing with the organic chemicals problem.

EPA believes that the intelligent approach to the organic chemicals question is to move ahead as rapidly as possible along two fronts. First, EPA is adopting simultaneously with these regulations a Subpart E of Part 141, containing requirements for organic chemical monitoring pursuant to Sections 1445 and 1450 of the Act.

The regulations require that designated public water systems collect samples of raw and treated water for submission to EPA for organics analysis. EPA will analyze the samples for a number of broad organic parameters, including carbon chloroform extract (CCE), volatile and non-volatile total organic carbon (VTOC and NVTOC), total organic chlorine (TOCl), ultraviolet absorbancy, and fluorescence. In addition, monitoring will be required for probably 21 specific organic compounds. Selection of the specific compounds has been based on the occurrence or likelihood of occurrence in treated water, toxicity data and availability of practical analytical methods. Laboratory analyses will be used to evaluate the extent and nature of organic chemical contamination of drinking water, to evaluate the validity of the general organic parameters as surrogates for measures of harmful organic chemicals, and to determine whether there is an adequate basis for establishing maximum contaminant levels for specific organics or groups of organics.

Second, EPA is embarking on an intensive research program to find answers to the following four questions:

1. What are the effects of commonly occurring organic compounds on human health?

2. What analytical procedures should be used to monitor finished drinking water to assure that any Primary Drinking Water Regulations dealing with organics are met?

3. Because some of these organic compounds are formed during water treatment, what changes in treatment practices are required to minimize the formation of these compounds in treated water?

4. What treatment technology must be applied to reduce contaminant levels to concentrations that may be specified in the Primary Drinking Water Regulations?

This research will involve health-effects and epidemiological studies, investigations of analytical methodology, and pilot plant and field studies of organic removal unit processes. Some phases of the research are to be completed by the end of this year, while much of the remainder are to be completed within the next calendar year.

As soon as sufficient information is derived from the monitoring program and related research, the Interim Primary Drinking Water Regulations will be amended so that the organic chemicals problem can be dealt with without delay. The monitoring process will be completed within 1 year.

During the interim period, while satisfactory MCL's for organic contamination in drinking water are being developed, EPA will act in specific cases where appropriate to deal with organic contamination. If the EPA monitoring program reveals serious specific cases of contamination, EPA will work with State and local authorities to identify the source and nature of the problem and to

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take remedial action. EPA will also aid the States in identifying additional community water supplies that require analysis.

PUBLIC NOTICE

The public notice requirements proposed in § 141.32 did not distinguish between community and non-community public water systems. They would have required that public notice of non-compliance with applicable regulations be made by newspaper, in water bills, and by other media for all public water systems. These requirements are inappropriate and ineffective in the case of most non-community water systems. Those systems principally serve transients who do not receive water bills from the system and who probably are not exposed significantly to the local media. A more effective approach would be to require notice that can inform the transient before he drinks the system's water, and thereby both warn the transient and provide an incentive to the supplier of water to remedy the violation. Accordingly, Section 141.32 as adopted provides that in the case of non-community systems, the entity with primary enforcement responsibility shall require that notice be given in a form and manner that will insure that the public using the public water system is adequately informed.

The proposed public notice requirements also failed to distinguish between different types of violations of the Interim Primary Drinking Water Regulations. Since the urgency and importance of a notice varies according to the nature of the violation involved, § 141.32 as promulgated seeks to match the type of notice required with the type of violation involved. Written notice accompanying a water bill or other direct notice by mail is required for all violations of the regulations, including violations of monitoring requirements, and for the grant of a variance or exemption. In addition, notice by newspaper and notification to radio and television stations is required whenever a maximum contaminant level is exceeded, or when the entity with primary enforcement responsibility requires such broader notice.

QUALITY CONTROL AND TESTING PROCEDURES

Section 1401(1) of the Act defines "primary drinking water regulation" to include "quality control and testing procedures." The promulgated regulations include testing requirements for each maximum contaminant level, including check samples and special samples in appropriate cases. The regulations also specify the procedures to be followed in analyzing samples for each of the maximum contaminant levels. These procedures will be updated from time to time as advances are made in analytical methods. For example, references to "Standard Methods for the Examination of Water and Wastewater" are to the current, 13th, edition, but these references will be changed to cite the 14th edition when it is available in the near future.

A key element of quality control for public water systems is accurate laboratory analysis. Section 141.28 of the regulations provides that analyses conducted for the purpose of determining compliance with maximum contaminant levels must be conducted by a laboratory approved by the entity with primary enforcement responsibility. EPA will develop as soon as possible, in cooperation with the States and other interested parties, criteria and procedures for laboratory certification. A State with primary enforcement responsibility will have a laboratory certified by EPA pursuant to the prescribed criteria and procedures, and in turn will certify laboratories within the State.

Record-keeping requirements and reports to the State also will assist in quality control efforts.

RECORD-KEEPING

Adequate record-keeping is necessary for the proper operation and administration of a public water system. It is also important for providing information to the public, providing appropriate data for inspection and enforcement activities and providing information on which future regulations can be based. Accordingly, a new § 141.33 has been added to the regulations to require that each public water system maintain records of sample analyses and of actions to correct violations of the Primary Drinking Water Regulations.

ECONOMIC AND COST ANALYSIS

A comprehensive economics study has been made of the Interim Primary Drinking Water Regulations. This study estimates the costs of the regulations, evaluates the potential economic impact, and considers possible material and labor shortages. The results of this analysis are summarized here.

Total investment costs to community water systems to achieve compliance with these regulations are estimated to be between $1,050 and $1,765 million. It is estimated that non-community systems will invest an additional $24 million. The range of the estimate is due to uncertainty as to the design flow that will be used in installing treatment facilities. Systems not in compliance will have to consider sizing their new components to reflect average daily flow conditions, or maximum daily flow conditions in cases where system storage is not adequate.

This investment will be spread over several years. Investor-owned systems will bear about one-fourth of these costs, and publicly-owned systems the remainder. It is not anticipated that systems will have difficulty financing these capital requirements.

In annual terms, national costs are expected to be within the following ranges:

	In millions
Capital costs	$146–247
Operations and maintenance	263–363
Monitoring (routine only)	17– 35
Total	$426–645

Although these aggregate figures are large, most water consumers will not be significantly affected. For those users in systems serving 10,000 persons or more, the average annual treatment cost per capita may increase from less than $1.00 for systems requiring disinfection and lead control, to between $15 to $35 for control of turbidity and heavy metal removal. For systems serving less than 100 persons, the average annual per capita costs of disinfection, lead control and fluoride/arsenic removal are estimated to be between $2.10 and $11.80. However, if turbidity control or heavy metal removal were required in a system of this size then costs are expected to range from $52 to $237 per year per capita. EPA is aware of the serious potential economic impact on users in these small systems. However, the legislative history specifies that the regulations should be based on costs that can be reasonably afforded by large metropolitan or regional systems. Further economic evaluation of these systems is being conducted, and realistic options for these small systems are being reviewed. Options that will be under consideration include less costly treatment technologies; formation of regional systems; and use of alternative water sources. Industrial and commercial users, whether providing their own water or using public systems, are not expected to be significantly affected by these regulations.

Possible constraints to the implementation of the interim primary regulations were examined. Although there will be an increase in demand for chemicals, manpower, laboratories, and construction of treatment facilities, it is not anticipated that any of these factors will be a serious obstacle to implementation of these regulations over a reasonable time frame.

For the reasons given above, Chapter 40 of the Code of Federal Regulations is hereby amended by the addition of the following new Part 141. These regulations will take effect 18 months after promulgation.

(It is hereby certified that the economic and inflationary impacts of these regulations have been carefully evaluated in accordance with Executive Order 11821)

Dated: December 10, 1975.

RUSSELL E. TRAIN,
Administrator.

Subpart A—General

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Subpart D—Reporting, Public Notification, and Record-keeping

141.31 Reporting requirements.
141.32 Public notification of variances, exemptions, and non-compliance with regulations.
141.33 Record maintenance.

AUTHORITY: Secs. 1412, 1414, 1445, and 1450 of the Public Health Service Act, 88 Stat. 1660 (42 U.S.C. 300g–1, 300g–3, 300j–4, and 300j–9).

Subpart A—General

§ 141.1 Applicability.

This part establishes primary drinking water regulations, pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Pub. L. 93–523); and related regulations applicable to public water systems.

§ 141.2 Definitions.

As used in this part, the term:

(a) "Act" means the Public Health Service Act, as amended by the Safe Drinking Water Act, Pub. L. 93–523.

(b) "Contaminant" means any physical, chemical, biological, or radiological substance or matter in water.

(c) "Maximum contaminant level" means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

(d) "Person" means an individual, corporation, company, association, partnership, State, municipality, or Federal agency.

(e) "Public water system" means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system. A public water system is either a "community water system" or a "non-community water system."

(f) "Community water system" means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

(g) "Non-community water system" means a public water system that is not a community water system.

(h) "Sanitary survey" means an on-site review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation and maintenance for producing and distributing safe drinking water.

(i) "Standard sample" means the aliquot of finished drinking water that is examined for the presence of coliform bacteria.

(j) "State" means the agency of the State government which has jurisdiction over public water systems. During any period when a State does not have primary enforcement responsibility pursuant to Section 1413 of the Act, the term "State" means the Regional Administrator, U.S. Environmental Protection Agency.

(k) "Supplier of water" means any person who owns or operates a public water system.

§ 141.3 Coverage.

This part shall apply to each public water system, unless the public water system meets all of the following conditions:

(a) Consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(b) Obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(c) Does not sell water to any person; and

(d) Is not a carrier which conveys passengers in interstate commerce.

§ 141.4 Variances and exemptions.

Variances or exemptions from certain provisions of these regulations may be granted pursuant to Sections 1415 and 1416 of the Act by the entity with primary enforcement responsibility. Provisions under Part 142, *National Interim Primary Drinking Water Regulations Implementation*—subpart E (Variances) and subpart F (Exemptions)—apply where EPA has primary enforcement responsibility.

§ 141.5 Siting requirements.

Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase the capacity of an existing public water system, he shall notify the State and, to the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(a) Is subject to a significant risk from earthquakes, floods, fires or other disasters which could cause a breakdown of the public water system or a portion thereof; or

(b) Except for intake structures, is within the floodplain of a 100-year flood or is lower than any recorded high tide where appropriate records exist.

The U.S. Environmental Protection Agency will not seek to override land use decisions affecting public water systems siting which are made at the State or local government levels.

§ 141.6 Effective date.

The regulations set forth in this part shall take effect 18 months after the date of promulgation.

Subpart B—Maximum Contaminant Levels

§ 141.11 Maximum contaminant levels for inorganic chemicals.

(a) The maximum contaminant level for nitrate is applicable to both community water systems and non-community water systems. The levels for the other inorganic chemicals apply only to community water systems. Compliance with maximum contaminant levels for inorganic chemicals is calculated pursuant to § 141.23.

(b) The following are the maximum contaminant levels for inorganic chemicals other than fluoride:

Contaminant	*Level, milligrams per liter*
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05

(c) When the annual average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the maximum contaminant levels for fluoride are:

Temperature Degrees Fahrenheit	Degrees Celsius	Level, milligrams per liter
53.7 and below	12.0 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

§ 141.12 Maximum contaminant levels for organic chemicals.

The following are the maximum contaminant levels for organic chemicals. They apply only to community water systems. Compliance with maximum contaminant levels for organic chemicals is calculated pursuant to § 141.24.

	Level, milligrams per liter
(a) Chlorinated hydrocarbons:	
Endrin (1,2,3,4,10, 10-hexachloro-6,7-epoxy-1,4, 4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8 - dimethano naphthalene).	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer).	0.004
Methoxychlor (1,1,1-Trichloro-2, 2 - bis [p-methoxyphenyl] ethane).	0.1
Toxaphene ($C_{10}H_{10}Cl_8$,-Technical chlorinated camphene, 67–69 percent chlorine).	0.005

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(b) Chlorophenoxys:	
2,4 - D, (2,4-Dichlorophenoxyacetic acid).	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid).	0.01

§ 141.13 Maximum contaminant levels for turbidity.

The maximum contaminant levels for turbidity are applicable to both community water systems and non-community water systems using surface water sources in whole or in part. The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system, are:

(a) One turbidity unit (TU), as determined by a monthly average pursuant to § 141.22, except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not do any of the following:

(1) Interfere with disinfection;

(2) Prevent maintenance of an effective disinfectant agent throughout the distribution system; or

(3) Interfere with microbiological determinations.

(b) Five turbidity units based on an average for two consecutive days pursuant to § 141.22.

§ 141.14 Maximum microbiological contaminant levels.

The maximum contaminant levels for coliform bacteria, applicable to community water systems and non-community water systems, are as follows:

(a) When the membrane filter technique pursuant to § 141.21(a) is used, the number of coliform bacteria shall not exceed any of the following:

(1) One per 100 milliliters as the arithmetic mean of all samples examined per month pursuant to § 141.21 (b) or (c);

(2) Four per 100 milliliters in more than one sample when less than 20 are examined per month; or

(3) Four per 100 milliliters in more than five percent of the samples when 20 or more are examined per month.

(b) (1) When the fermentation tube method and 10 milliliter standard portions pursuant to § 141.21(a) are used, coliform bacteria shall not be present in any of the following:

(i) more than 10 percent of the portions in any month pursuant to § 141.21 (b) or (c);

(ii) three or more portions in more than one sample when less than 20 samples are examined per month; or

(iii) three or more portions in more than five percent of the samples when 20 or more samples are examined per month.

(2) When the fermentation tube method and 100 milliliter standard portions pursuant to § 141.21(a) are used, coliform bacteria shall not be present in any of the following:

(i) more than 60 percent of the portions in any month pursuant to § 141.21 (b) or (c);

(ii) five portions in more than one sample when less than five samples are examined per month; or

(iii) five portions in more than 20 percent of the samples when five or more samples are examined per month.

(c) For community or non-community systems that are required to sample at a rate of less than 4 per month, compliance with paragraphs (a), (b)(1), or (b)(2) of this section shall be based upon sampling during a 3 month period, except that, at the discretion of the State, compliance may be based upon sampling during a one-month period.

Subpart C—Monitoring and Analytical Requirements

§ 141.21 Microbiological contaminant sampling and analytical requirements.

(a) Suppliers of water for community water systems and non-community water systems shall analyze for coliform bacteria for the purpose of determining compliance with § 141.14. Analyses shall be conducted in accordance with the analytical recommendations set forth in "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, 13th Edition, pp. 662–688, except that a standard sample size shall be employed. The standard sample used in the membrane filter procedure shall be 100 milliliters. The standard sample used in the 5 tube most probable number (MPN) procedure (fermentation tube method) shall be 5 times the standard portion. The standard portion is either 10 milliliters or 100 milliliters as described in § 141.14 (b) and (c). The samples shall be taken at points which are representative of the conditions within the distribution system.

(b) The supplier of water for a community water system shall take coliform density samples at regular time intervals, and in number proportionate to the population served by the system. In no event shall the frequency be less than as set forth below:

Population served:	*Minimum number of samples per month*
25 to 1,000	1
1,001 to 2,500	2
2,501 to 3,300	3
3,301 to 4,100	4
4,101 to 4,900	5
4,901 to 5,800	6
5,801 to 6,700	7
6,701 to 7,600	8
7,601 to 8,500	9
8,501 to 9,400	10
9,401 to 10,300	11
10,301 to 11,100	12
11,101 to 12,000	13
12,001 to 12,900	14
12,901 to 13,700	15
13,701 to 14,600	16
14,601 to 15,500	17
15,501 to 16,300	18
16,301 to 17,200	19
17,201 to 18,100	20
18,101 to 18,900	21
18,901 to 19,800	22
19,801 to 20,700	23
20,701 to 21,500	24
21,501 to 22,300	25
22,301 to 23,200	26
23,201 to 24,000	27
24,001 to 24,900	28
24,901 to 25,000	29
25,001 to 28,000	30
28,001 to 33,000	35
33,001 to 37,000	40
37,001 to 41,000	45
41,001 to 46,000	50
46,001 to 50,000	55
50,001 to 54,000	60
54,001 to 59,000	65
59,001 to 64,000	70
64,001 to 70,000	75
70,001 to 76,000	80
76,001 to 83,000	85
83,001 to 90,000	90
90,001 to 96,000	95
96,001 to 111,000	100
111,001 to 130,000	110
130,001 to 160,000	120
160,001 to 190,000	130
190,001 to 220,000	140
220,001 to 250,000	150
250,001 to 290,000	160
290,001 to 320,000	170
320,001 to 360,000	180
360,001 to 410,000	190
410,001 to 450,000	200
450,001 to 500,000	210
500,001 to 550,000	220
550,001 to 600,000	230
600,001 to 660,000	240
660,001 to 720,000	250
720,001 to 780,000	260
780,001 to 840,000	270
840,001 to 910,000	280
910,001 to 970,000	290
970,001 to 1,050,000	300
1,050,001 to 1,140,000	310
1,140,001 to 1,230,000	320
1,230,001 to 1,320,000	330
1,320,001 to 1,420,000	340
1,420,001 to 1,520,000	350
1,520,001 to 1,630,000	360
1,630,001 to 1,730,000	370
1,730,001 to 1,850,000	380
1,850,001 to 1,970,000	390
1,970,001 to 2,060,000	400
2,060,001 to 2,270,000	410
2,270,001 to 2,510,000	420
2,510,001 to 2,750,000	430
2,750,001 to 3,020,000	440
3,020,001 to 3,320,000	450
3,320,001 to 3,620,000	460
3,620,001 to 3,960,000	470
3,960,001 to 4,310,000	480
4,310,001 to 4,690,000	490
4,690,001 or more	500

Based on a history of no coliform bacterial contamination and on a sanitary survey by the State showing the water system to be supplied solely by a protected ground water source and free of sanitary defects, a community water system serving 25 to 1,000 persons, with written permission from the State, may reduce this sampling frequency except that in no case shall it be reduced to less than one per quarter.

(c) The supplier of water for a non-community water system shall sample for coliform bacteria in each calendar quarter during which the system provides water to the public. Such sampling shall begin within two years after the effective date of this part. If the State, on the basis of a sanitary survey, determines that some other frequency is more appropriate, that frequency shall be the frequency required under these regulations. Such frequency shall be confirmed or changed on the basis of subsequent surveys.

(d) (1) When the coliform bacteria in a single sample exceed four per 100 milliliters (§ 141.14(a)), at least two consecutive daily check samples shall be collected and examined from the same sampling point. Additional check samples shall be collected daily, or at a frequency estab-

lished by the State, until the results obtained from at least two consecutive check samples show less than one coliform bacterium per 100 milliliters.

(2) When coliform bacteria occur in three or more 10 ml portions of a single sample (§ 141.14(b)(1)), at least two consecutive daily check samples shall be collected and examined from the same sampling point. Additional check samples shall be collected daily, or at a frequency established by the State, until the results obtained from at least two consecutive check samples show no positive tubes.

(3) When coliform bacteria occur in all five of the 100 ml portions of a single sample (§ 141.14(b)(2)), at least two daily check samples shall be collected and examined from the same sampling point. Additional check samples shall be collected daily, or at a frequency established by the State, until the results obtained from at least two consecutive check samples show no positive tubes.

(4) The location at which the check samples were taken pursuant to paragraphs (d) (1), (2), or (3) of this section shall not be eliminated from future sampling without approval of the State. The results from all coliform bacterial analyses performed pursuant to this subpart, except those obtained from check samples and special purpose samples, shall be used to determine compliance with the maximum contaminant level for coliform bacteria as established in § 141.14. Check samples shall not be included in calculating the total number of samples taken each month to determine compliance with § 141.21 (b) or (c).

(e) When the presence of coliform bacteria in water taken from a particular sampling point has been confirmed by any check samples examined as directed in paragraphs (d) (1), (2), or (3) of this section, the supplier of water shall report to the State within 48 hours.

(f) When a maximum contaminant level set forth in paragraphs (a), (b) or (c) of § 141.14 is exceeded, the supplier of water shall report to the State and notify the public as prescribed in § 141.31 and § 141.32.

(g) Special purpose samples, such as those taken to determine whether disinfection practices following pipe placement, replacement, or repair have been sufficient, shall not be used to determine compliance with § 141.14 or § 141.21 (b) or (c).

(h) A supplier of water of a community water system or a non-community water system may, with the approval of the State and based upon a sanitary survey, substitute the use of chlorine residual monitoring for not more than 75 percent of the samples required to be taken by paragraph (b) of this section, *Provided*, That the supplier of water takes chlorine residual samples at points which are representative of the conditions within the distribution system at the frequency of at least four for each substituted microbiological sample. There shall be at least daily determinations of chlorine residual. When the supplier of water exercises the option provided in this paragraph (h) of this section, he shall maintain no less than 0.2 mg/1 free chlorine throughout the public water distribution system. When a particular sampling point has been shown to have a free chlorine residual less than 0.2 mg/1, the water at that location shall be retested as soon as practicable and in any event within one hour. If the original analysis is confirmed, this fact shall be reported to the State within 48 hours. Also, if the analysis is confirmed, a sample for coliform bacterial analysis must be collected from that sampling point as soon as practicable and preferably within one hour, and the results of such analysis reported to the State within 48 hours after the results are known to the supplier of water. Analyses for residual chlorine shall be made in accordance with "Standard Methods for the Examination of Water and Wastewater," 13th Ed., pp. 129–132. Compliance with the maximum contaminant levels for coliform bacteria shall be determined on the monthly mean or quarterly mean basis specified in § 141.14, including those samples taken as a result of failure to maintain the required chlorine residual level. The State may withdraw its approval of the use of chlorine residual substitution at any time.

§ 141.22 Turbidity sampling and analytical requirements.

(a) Samples shall be taken by suppliers of water for both community water systems and non-community water systems at a representative entry point(s) to the water distribution system at least once per day, for the purpose of making turbidity measurements to determine compliance with § 141.13. The measurement shall be made by the Nephelometric Method in accordance with the recommendations set forth in "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, 13th Edition, pp. 350–353, or "Methods for Chemical Analysis of Water and Wastes," pp. 295–298, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(b) If the result of a turbidity analysis indicates that the maximum allowable limit has been exceeded, the sampling and measurement shall be confirmed by resampling as soon as practicable and preferably within one hour. If the repeat sample confirms that the maximum allowable limit has been exceeded, the supplier of water shall report to the State within 48 hours. The repeat sample shall be the sample used for the purpose of calculating the monthly average. If the monthly average of the daily samples exceeds the maximum allowable limit, or if the average of two samples taken on consecutive days exceeds 5 TU, the supplier of water shall report to the State and notify the public as directed in § 141.31 and § 141.32.

(c) Sampling for non-community water systems shall begin within two years after the effective date of this part.

(d) The requirements of this § 141.22 shall apply only to public water systems which use water obtained in whole or in part from surface sources.

§ 141.23 Inorganic chemical sampling and analytical requirements.

(a) Analyses for the purpose of determining compliance with § 141.11 are required as follows:

(1) Analyses for all community water systems utilizing surface water sources shall be completed within one year following the effective date of this part. These analyses shall be repeated at yearly intervals.

(2) Analyses for all community water systems utilizing only ground water sources shall be completed within two years following the effective date of this part. These analyses shall be repeated at three-year intervals.

(3) For non-community water systems, whether supplied by surface or ground water sources, analyses for nitrate shall be completed within two years following the effective date of this part. These analyses shall be repeated at intervals determined by the State.

(b) If the result of an analysis made pursuant to paragraph (a) indicates that the level of any contaminant listed in § 141.11 exceeds the maximum contaminant level, the supplier of water shall report to the State within 7 days and initiate three additional analyses at the same sampling point within one month.

(c) When the average of four analyses made pursuant to paragraph (b) of this section, rounded to the same number of significant figures as the maximum contaminant level for the substance in question, exceeds the maximum contaminant level, the supplier of water shall notify the State pursuant to § 141.31 and give notice to the public pursuant to § 141.32. Monitoring after public notification shall be at a frequency designated by the State and shall continue until the maximum contaminant level has not been exceeded in two successive samples or until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective.

(d) The provisions of paragraphs (b) and (c) of this section notwithstanding, compliance with the maximum contaminant level for nitrate shall be determined on the basis of the mean of two analyses. When a level exceeding the maximum contaminant level for nitrate is found, a second analysis shall be initiated within 24 hours, and if the mean of the two analyses exceeds the maximum contaminant level, the supplier of water shall report his findings to the State pursuant to § 141.31 and shall notify the public pursuant to § 141.32.

(e) For the initial analyses required by paragraph (a)(1), (2) or (3) of this section, data for surface waters acquired within one year prior to the effective date and data for ground waters acquired within 3 years prior to the effective date of this part may be substituted at the discretion of the State.

(f) Analyses conducted to determine compliance with § 141.11 shall be made in accordance with the following methods:

(1) Arsenic—Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," pp. 95–96, Environ-

mental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(2) Barium—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 97–98, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(3) Cadmium—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 101–103, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(4) Chromium—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 105–106, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(5) Lead—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 112–113, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(6) Mercury—Flameless Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," pp. 118–126, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(7) Nitrate—Brucine Colorimetric Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 461–464, or Cadmium Reduction Method, "Methods for Chemical Analysis of Water and Wastes," pp. 201–206, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(8) Selenium—Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," p. 145, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(9) Silver—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater", 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes", p. 146, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(10) Fluoride—Electrode Method, "Standard Methods for the Examination of Water and Wastewater", 13th Edition, pp. 172–174, or "Methods for Chemical Analysis of Water and Wastes," pp. 65–67, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974, or Colorimetric Method with Preliminary Distillation, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 171–172 and 174–176, or "Methods for Chemical Analysis of Water and Wastes," pp. 59–60, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

§ 141.24 Organic chemical sampling and analytical requirements.

(a) An analysis of substances for the purpose of determining compliance with § 141.12 shall be made as follows:

(1) For all community water systems utilizing surface water sources, analyses shall be completed within one year following the effective date of this part. Samples analyzed shall be collected during the period of the year designated by the State as the period when contamination by pesticides is most likely to occur. These analyses shall be repeated at intervals specified by the State but in no event less frequently than at three year intervals.

(2) For community water systems utilizing only ground water sources, analyses shall be completed by those systems specified by the State.

(b) If the result of an analysis made pursuant to paragraph (a) of this section indicates that the level of any contaminant listed in § 141.12 exceeds the maximum contaninant level, the supplier of water shall report to the State within 7 days and initiate three additional analyses within one month.

(c) When the average of four analyses made pursuant to paragraph (b) of this section, rounded to the same number of significant figures as the maximum contaminant level for the substance in question, exceeds the maximum contaminant level, the supplier of water shall report to the State pursuant to § 141.31 and give notice to the public pursuant to § 141.32. Monitoring after public notification shall be at a frequency designated by the State and shall continue until the maximum contaminant level has not been exceeded in two successive samples or until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective.

(d) For the initial analysis required by paragraph (a) (1) and (2) of this section, data for surface water acquired within one year prior to the effective date of this part and data for ground water acquired within three years prior to the effective date of this part may be substituted at the discretion of the State.

(e) Analyses made to determine compliance with § 141.12(a) shall be made in accordance with "Method for Organochlorine Pesticides in Industrial Effluents," MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

(f) Analyses made to determine compliance with § 141.12(b) shall be conducted in accordance with "Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

§ 141.27 Alternative analytical techniques.

With the written permission of the State, concurred in by the Administrator of the U.S. Environmental Protection Agency, an alternative analytical technique may be employed. An alternative technique shall be acceptable only if it is substantially equivalent to the prescribed test in both precision and accuracy as it relates to the determination of compliance with any maximum contaminant level. The use of the alternative analytical technique shall not decrease the frequency of monitoring required by this part.

§ 141.28 Approved laboratories.

For the purpose of determining compliance with § 141.21 through § 141.27, samples may be considered only if they have been analyzed by a laboratory approved by the State except that measurements for turbidity and free chlorine residual may be performed by any person acceptable to the State.

§ 141.29 Monitoring of consecutive public water systems.

When a public water system supplies water to one or more other public water systems, the State may modify the monitoring requirements imposed by this part to the extent that the interconnection of the sysems jusifies treating them as a single system for monitoring purposes. Any modified monitoring shall be conducted pursuant to a schedule specified by the State and concurred in by the Administrator of the U.S. Environmental Protection Agency.

Subpart D—Reporting, Public Notification and Record Keeping

§ 141.31 Reporting requirements.

(a) Except where a shorter reporting period is specified in this part, the supplier of water shall report to the State within 40 days following a test, measurement or analysis required to be made by this part, the results of that test, measurement or analysis.

(b) The supplier of water shall report to the State within 48 hours the failure to comply with any primary drinking water regulation (including failure to comply with monitoring requirements) set forth in this part.

(c) The supplier of water is not required to report analytical results to the State in cases where a State laboratory performs the analysis and reports the results to the State office which would normally receive such notification from the supplier.

§ 141.32 Public notification.

(a) If a community water system fails to comply with an applicable maximum contaminant level established in Subpart B, fails to comply with an applicable testing procedure established in Subpart C of this part, is granted a variance or an exemption from an applicable maximum contaminant level, fails to comply with the requirements of any schedule prescribed pursuant to a variance or exemption, or fails to perform any monitoring required pursuant to Section 1445 (a) of the Act, the supplier of water shall notify persons served by the system of the failure or grant by inclusion of a notice in the first set of water bills of the system issued after the failure or grant

and in any event by written notice within three months. Such notice shall be repeated at least once every three months so long as the system's failure continues or the variance or exemption remains in effect. If the system issues water bills less frequently than quarterly, or does not issue water bills, the notice shall be made by or supplemented by another form of direct mail.

(b) If a community water system has failed to comply with an applicable maximum contaminant level, the supplier of water shall notify the public of such failure, in addition to the notification required by paragraph (a) of this section, as follows:

(1) By publication on not less than three consecutive days in a newspaper or newspapers of general circulation in the area served by the system. Such notice shall be completed within fourteen days after the supplier of water learns of the failure.

(2) By furnishing a copy of the notice to the radio and television stations serving the area served by the system. Such notice shall be furnished within seven days after the supplier of water learns of the failure.

(c) If the area served by a community water system is not served by a daily newspaper of general circulation, notification by newspaper required by paragraph (b) of this section shall instead be given by publication on three consecutive weeks in a weekly newspaper of general circulation serving the area. If no weekly or daily newspaper of general circulation serves the area, notice shall be given by posting the notice in post offices within the area served by the system.

(d) If a non-community water system fails to comply with an applicable maximum contaminant level established in Subpart B of this part, fails to comply with an applicable testing procedure established in Subpart C of this part, is granted a variance or an exemption from an applicable maximum contaminant level, fails to comply with the requirement of any schedule prescribed pursuant to a variance or exemption or fails to perform any monitoring required pursuant to Section 1445(a) of the Act, the supplier of water shall given notice of such failure or grant to the persons served by the system. The form and manner of such notice shall be prescribed by the State, and shall insure that the public using the system is adequately informed of the failure or grant.

(e) Notices given pursuant to this section shall be written in a manner reasonably designed to inform fully the users of the system. The notice shall be conspicuous and shall not use unduly technical language, unduly small print or other methods which would frustrate the purpose of the notice. The notice shall disclose all material facts regarding the subject including the nature of the problem and, when appropriate, a clear statement that a primary drinking water regulation has been violated and any preventive measures that should be taken by the public. Where appropriate, or where designated by the State, bilingual notice shall be given. Notices may include a balanced explanation of the significance or seriousness to the public health of the subject of the notice, a fair explanation of steps taken by the system to correct any problem and the results of any additional sampling.

(f) Notice to the public required by this section may be given by the State on behalf of the supplier of water.

(g) In any instance in which notification by mail is required by paragraph (a) of this section but notification by newspaper or to radio or television stations is not required by paragraph (b) of this section, the State may order the supplier of water to provide notification by newspaper and to radio and television stations when circumstances make more immediate or broader notice appropriate to protect the public health.

§ 141.33 Record maintenance.

Any owner or operator of a public water system subject to the provisions of this part shall retain on its premises or at a convenient location near its premises the following records:

(a) Records of bacteriological analyses made pursuant to this part shall be kept for not less than 5 years. Records of chemical analyses made pursuant to this part shall be kept for not less than 10 years. Actual laboratory reports may be kept, or data may be transferred to tabular summaries, provided that the following information is included:

(1) The date, place, and time of sampling, and the name of the person who collected the sample;

(2) Identification of the sample as to whether it was a routine distribution system sample, check sample, raw or process water sample or other special purpose sample;

(3) Date of analysis;

(4) Laboratory and person responsible for performing analysis;

(5) The analytical technique/method used; and

(6) The results of the analysis.

(b) Records of action taken by the system to correct violations of primary drinking water regulations shall be kept for a period not less than 3 years after the last action taken with respect to the particular violation involved.

(c) Copies of any written reports, summaries or communications relating to sanitary surveys of the system conducted by the system itself, by a private consultant, or by any local, State or Federal agency, shall be kept for a period not less than 10 years after completion of the sanitary survey involved.

(d) Records concerning a variance or exemption granted to the system shall be kept for a period ending not less than 5 years following the expiration of such variance or exemption.

Page excerpted from: Manual for the Interim Certification of Laboratories Involved in Analyzing Public Drinking Water Supplies, September 1977. U.S. EPA.

FREE CHLORINE RESIDUAL AND TURBIDITY

Free chlorine residual and turbidity measurements do not need to be done in approved laboratories, but may be performed by any persons acceptable to the State. There is, however, a definite need for quality control guidelines to be instituted at the State level for these measurements; it is equally important that systems be in use to assure validity of data for these critical measurements. If the criteria below are met, the States should be able to approve persons performing the measurements.

Free Chlorine Residual

The following are criteria for free chlorine residual measurements:

- Method: DPD Colorimetric Method, described on pages 129-132 in "Standard Methods for the Examination of Water and Wastewater," 13th edition.
- Sample preservation: None; analyses must be made as soon as practicable, or within 1 hour.
- Sample container: Plastic or glass.
- Equipment: DPD Colorimetric Test Kit, or spectrophotometer or photometer.

Turbidity

Criteria for measuring turbidity are the following:

- Method: Nephelometric, described on pages 350-353 in "Standard Methods for the Examination of Water and Wastewater," 13th edition, and on pages 295-298 in EPA's "Methods for Chemical Analysis of Water and Wastes."
- Sample preservation: None; analyses must be made as soon as practicable or within 1 hour.
- Sample container: Plastic or glass.
- Equipment: Nephelometer
- Calibration of sealed liquid turbidity standards: Sealed liquid turbidity standards purchased from the instrument manufacturer must be calibrated against properly prepared and diluted formazin standards at least every 4 months in order to monitor their eventual deterioration. These standards should be replaced when any major change from the previous calibration occurs. Solid turbidity standards composed of plastic, glass, or other materials are not reliable and should not be used.

cept of laboratory certification, although there were a few requests for clarification of the role of the certifying authority. Most of the comments contained objections to the concept of requiring turbidity and chlorine residual tests to be performed by certified laboratories. The remaining comments addressed the cost of certification, the need for time to get labs certified, and the scarcity of qualified laboratories.

It was the intent of the Administrator that EPA would certify at least one laboratory in each State with other laboratories to be certified by the State laboratory or laboratories qualified to perform this function. Because of the transient nature of turbidity and chlorine residual values, it is not possible for a public water system to collect samples and transmit them to a central laboratory for determination of these parameters. It was the intent of the Administrator that the individual operators of public water systems perform their own turbidity and chlorine residual analyses. It would seem advisable, however, that such operators be certified, approved, or at least minimally trained to perform the analytical tasks before a State could accept their analytical determinations as having enough validity for decisions regarding compliance or noncompliance to be made.

VII. Reporting and Public Notification

1. *Reporting.* There were over 200 comments on § 141.31, dealing with reporting requirements, but only three basic criticisms; the reporting requirement should be limited to those situations which are essential to enforcement of the regulations; the section needs clarification; and the institution of reporting requirements makes compliance with the regulations either difficult or impossible. Minor comments included requests for changes in the 36-hour and 40-day reporting requirements, requests for a corrective action requirement rather than a reporting requirement, and requests that Federal agencies report to the States rather than to EPA.

Section 1413 of the Public Health Service Act deals with the role of the States in implementing and enforcing drinking water regulations. Section 1414 of the Act spells out actions to be taken if a State fails to assure enforcement of drinking water regulations. A State could not effectively comply with the provisions of these sections without receiving regular reports from every public water system within its jurisdiction. Monitoring frequencies have been established, and if only violations of maximum contaminant levels were reported the State would not know whether or not monitoring frequencies had been adhered to. Thus all activities of a supplier of water in connection with these regulations are essential to enforcement of the regulations and must be reported to the State.

It is apparent from Section 1447 of the Public Health Service Act and the legislative history of the Safe Drinking Water Act that Federal agencies are to be treated exactly like any other owner or operator of a public water system, except in cases involving national security. Therefore, the Administrator believes that it would be contrary to the intent of the Act to require Federal agencies to report only to EPA and not to States with primary enforcement responsibility. In the revision of § 141.31 of these regulations, no exemption for Federal agencies from the provisions of the regulations will be specified.

2. *Public Notification.* Section 141.32, the public notification provision, received a large number of comments. Of the more than 300 comments, only two approved of this section as written. Two additional comments contained suggestions for modification, such as, for example, to require a second notice to tell the public that the condition previously reported had now been corrected. Every other comment expressed opposition to public notification, either on the basis of disagreement with the concept, on the basis of inappropriateness for some types of water systems, or on the basis of some type of inequity. Most frequently heard comments were: the State should have the authority to notify consumers only if there is an immediate and significant threat to public health; scare tactics will lead to public disregard; notification by radio and TV within 36 hours is an unreasonable requirement; notification of the entire public is unreasonable when only a portion of the public is involved; and notification by means of water bills is unacceptable. One of the more constructive comments was that, while the concept of public notification was opposed, the supplier of water should be given the opportunity to explain the deficiency.

To explain the intent of Congress in requiring public notification, the following is quoted from House Report No. 93-1185:

"The purpose of this notice requirement is to educate the public as to the extent to which public water systems serving them are performing inadequately in light of the objectives and requirements of this bill. Such public education is deemed essential by the Committee in order to develop public awareness of the problems facing public water systems, to encourage a willingness to support greater expenditure at all levels of government to assist in solving these problems, and to advise the public of potential or actual health hazards."

The Administrator agrees that the supplier should be given the opportunity to explain the deficiency. It was not the intent of Congress, that such notices would be merely a flat statement that the water system had failed to meet the requirements of the Regulations. To quote the House Report further:

"the Committee expects that the Administrator's regulations would permit public water systems to give fair explanation of the significance or seriousness for the public health of any violation, failure, exemption or variance. These regulations should also permit fair explanation of steps taken by the system to correct any problem."

The wording has therefore been modified to permit that the supplier may use the notice to explain the significance or seriousness of the violation, to include the results of additional (subsequent) sampling, and to indicate preventative measures that should be taken by the public.

As to the unreasonableness of allowing only 36 hours prior to radio and TV notification, this wording has been modified to read 48 hours and the Administrator believes that this is adequate time to prepare such notification when an MCL is violated.

Time requirements for notification in newspapers has been established. The regulations require that the failure of any MCL shall be published in a daily newspaper or newspapers of general circulation in the area served by the system, on not less than three consecutive days, and that such notification is to be completed within seven days after the supplier learns of the failure. The notice shall be provided to radio and television stations within 48 hours after he learns of the failure.

Public notice for other failures of the regulations, such as failure to comply with testing procedures, failure to comply with monitoring requirements, and failure to comply with a schedule prescribed pursuant to a variance or exemption, is to be made by including a notice with the water bills, within at least three months after the supplier learns of the failure. In the event water bills are not issued, there is a provision for using another form of direct mail.

The provision for mailing notices responds at least in part to the comment that the notice should not be made to the entire public but only to the portion of the public using the water. Otherwise, it is true that a notice given in a newspaper of general distribution, or a radio or television broadcast, will reach more people than those affected by a particular public water system.

There is no way that this can be avoided, but there is nothing in the regulations which would prevent the notice from specifying which person or which area need be concerned about the notice.

The Administrator agrees that the proposed public notice provisions are inappropriate for non-community water systems. Notices in the local media and in water bills will not have the intended effect with these systems serving transients or intermittent users. Therefore, § 141.32 has been revised to include a provision for other types of notification, subject to approval by the State, for non-community water systems. Envisioned here are such types of notification as a poster or sign near the drinking fountain of a facility serving the traveling public, or a handbill distributed to factory workers.

VIII. Economic Considerations

There were over 100 comments on the economic aspects of the regulations. The two most frequent comments were that the estimates in the preamble were much too low, and that the economic impact on the smaller water utilities would be severe. The corrective measure suggested in most cases was that EPA should give grants to the public water systems or should provide funds to the States to pay for monitoring. In general, the comments contained criticisms of the regulations in that they were termed "not cost effective."

It was the intent of Congress that the bulk of the costs associated with the Safe Drinking Water Act would be borne by the individual public water systems and thus the consumers. Of all the comments on the cost of a program to improve the quality of drinking water, it is noteworthy that only one comment stressed the benefits to those consumers.

There is no doubt that money will be spent for increased monitoring. This is particularly true for the smaller water systems, where in the past practically no monitoring has been performed. These very small water systems are the ones which most need improvement, so it can be expected that the costs will be proportionately higher for the small systems when compared with larger systems. On a per capita basis, since so few customers are involved, the costs will be disproportionately higher for the smaller systems. Congress did not intend that the monitoring costs for these systems would be subsidized. Rather, Congress hoped that many small systems would be consolidated into larger systems, so that the costs would be shared by a larger number of consumers, and so that improved drinking water quality would more easily be attained.

A cost and economic analysis of the monitoring requirements are attached as Appendix B.

IX. Other Comments

1. *Siting.* Of the more than 70 comments on § 141.41, siting requirements, most either wanted the section deleted or else clarified in some way. The criticisms were that the requirements for siting were not realistic, that the terms used needed definitions, that State